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The Sizes of California Sardines Caught by the Different Fishing Gear and in the Different Localities of the Monterey and San Pedro Regions

By the
CALIFORNIA STATE FISHERIES LABORATORY

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FOREWORD

The following two reports, on the sizes of sardines taken by various kinds of fishing gear and caught in different areas of the Monterey and of the San Pedro fishing regions, present the results of an investigation made to determine whether or not the system of sardine sampling as carried on in the past is still adequate since changes have occurred in the fishery. The results are of importance to the industry because they show that lampara, purse seine and ring nets all take the same sizes of fish, that these sizes comprise the sardines available to the fishermen, and that no type of gear exhibits size selection differing from any other type. Of greater importance to the industry is the evidence indicating that large fish first appear each winter to the north of Monterey and gradually become disseminated southward throughout the entire Monterey region, whereas in the San Pedro region no consistent distribution of differential sizes within the region is evident. The results are of value to the sardine investigation because of the demonstration of the continual reliability of our sardine sampling system and the furnishing of additional evidence indicating a southward movement of sardines along the California coast during the winter months.

The authors of these papers wish to acknowledge their indebtedness to Mr. W. L. Scofield of the California State Fisheries Laboratory, and to other members of the staff, for their assistance and advice in the preparation of these reports.

J. B. Phillips.

G. H. Clark.

October, 1931.

THE SIZES OF SARDINES CAUGHT BY DIFFERENT FISHING GEAR AND IN DIFFERENT LOCALITIES OF THE MONTEREY REGION[1]

By J. B. PHILLIPS

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INTRODUCTION

Commercial fishing for the sardine (*Sardina caerulea*) in the Monterey region is no longer restricted to the use of one type of fishing gear, nor is the fishing confined to adjacent waters. Of recent years, changes in the types of nets and boats used in sardine fishing and expansion of fishing waters have greatly manifested themselves. It has become highly desirable, therefore, to arrive at an early solution of the following questions, if we are to know the adequacy of the present system of sampling the commercial sardine catch:

1. Is there a difference in the sizes of sardines caught by the different fishing gear?

2. Is there a difference in the sizes of sardines caught in the various localities?

The 1929–1930 sardine season marked a turning point regarding fishing gear and fishing localities in the Monterey region. It was with this season that the virtual fishing gear monopoly enjoyed by the lampara net fishermen was broken. The greatest contributing factor was the increasing length of the period of scarcity of sardines in the adjacent waters (Lindner, 1930). The influx of the purse seine boats with their greater cruising radius and quicker impounding net made it necessary for the lampara captains to meet the competition along the

[1] Contribution No. 113 from the California State Fisheries Laboratory.

same lines. The lampara net was discarded in favor of the ring net, and some of the lampara captains rented or purchased purse seine boats.

From the time that sampling of the commercial sardine catch was commenced in 1919 only one type of net was used in sardine fishing until 1926. This was the lampara or round haul net (Higgins and

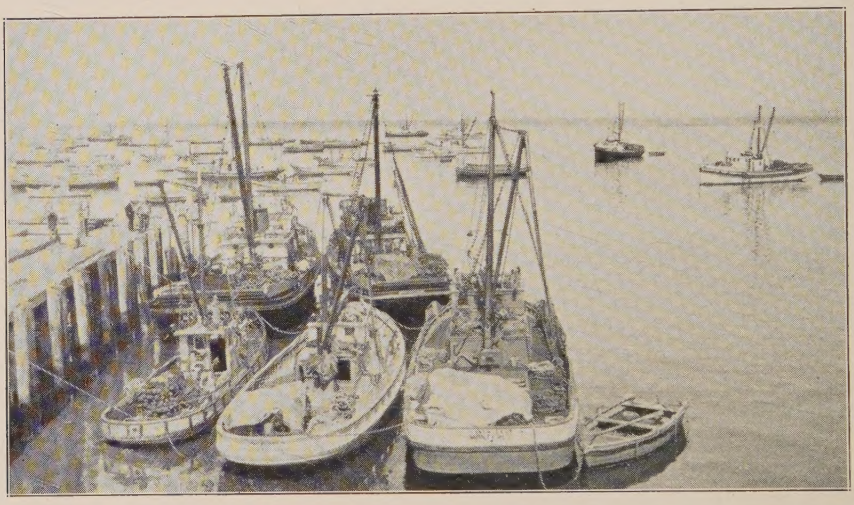

FIG. 1. Sardine fishing boats tied to Fishermen's Wharf at Monterey. These boats represent various types used in the Monterey region during the past two seasons. From left to right, the lower row: (1) A lampara launch that uses a ring net. This type of boat tows a lighter (see Fig. 2). Until 1930 this unit used a lampara net. (2) A new, large type of lampara launch that uses a ring net. This boat also tows a lighter. (3) A small purse seine type of boat using a ring net. The upper row shows two sizes of purse seine boats that use purse seines. The heavier construction of the purse seine makes it necessary to operate the net with the aid of a turntable. Photograph by J. B. Phillips, September, 1930.

Holmes, 1921; Scofield, N. B., 1924.1; Scofield, W. L., 1929). From 1926 until 1929 the purse seine played a small part in the sardine fishing (Scofield, N. B., 1924.2; Scofield, W. L., 1926; Skogsberg, 1925). During this period two purse seine nets were in operation. However, during the same period there were from 55 to 61 lampara nets in operation, so that the purse seine catch formed but a small portion of the total commercial catch. It was during the 1929–1930 season that the competition of the purse seine became so serious as to cause the abandonment of the lampara or round haul net in favor of the ring net (Fry, 1931; Phillips, 1930).

Since the beginning of sampling in 1919, there has been a gradual extension of the locality fished. This expansion of fishing area has been from the locality adjacent to Monterey, northward[2] to Halfmoon Bay, which is about 70 statute miles from Monterey. However, extended trips outside Monterey Bay were made only when weather conditions were favorable, because of the smallness of the lampara launches and the fact that they needed to tow a barge or lighter into which the catch

[2] Up to the present (1931) the water to the southward of Monterey Bay is undeveloped as far as sardine fishing in the Monterey region is concerned. This is due mainly to "bad currents" that interfere with the proper manipulation of the nets.

was loaded. The 1929–1930 season brought an influx of purse seine boats. These larger boats were able to cruise great distances because of their size and also their cheaper fuel consumption. During periods of scarcity in the home waters, trips to Halfmoon Bay were frequently made by the purse seine boats and occasionally as far northward as Point Reyes, which is about 115 statute miles from Monterey.

DATA AVAILABLE

Since this paper constitutes a report on the influence of gear and locality on the sizes of sardines caught in the Monterey region, none of our data collected previous to 1929 can be used. From 1919 when our study began until 1929, no significant changes in gear and locality occurred. Thus the material on hand for a comprehensive study of the influence of fishing gear and fishing localities on the sizes of sardines caught in the Monterey region is reduced at the present writing to the 1929–1930 and 1930–1931 seasons.

All of the following data are based on the semiweekly sampling of the commercial sardine catch. Five samples of 50 fish each make up a sample day representing a half-week. For each sample the following data are obtained from a member of the crew from whose boat the sample is taken: (1) name of boat and captain; (2) type of boat and net used in making catch; (3) locality of catch; (4) approximate

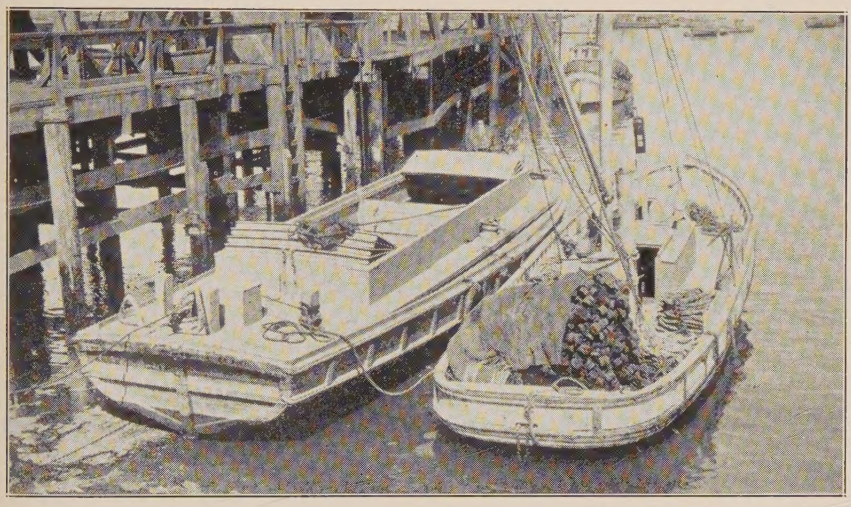

FIG. 2. A representative launch and lighter used for sardine fishing at Monterey. The lighter is towed by the launch on the fishing trips and the catch is loaded into it. This combination is known as a "lampara boat" in this paper, regardless of the type of net used. The above launch has a ring net piled on the stern. Photograph by J. B. Phillips, September, 1930.

number of tons delivered; (5) limit set by cannery; (6) number of hauls required to make up catch; (7) number of tons per haul; and (8) time of hauls.

Two measurements are taken for each fish: the body length and the total length. The body length measurement is used in this report and is the length from tip of the jaw (mouth closed) to the termination

of the skin at the base of the caudal fin. The total length measurement is a check on the body length measurement and is from the tip of the jaw (mouth closed) to the end of the caudal fin. In this case, the edges of the caudal fin are brought parallel to the longitudinal axis of the body.

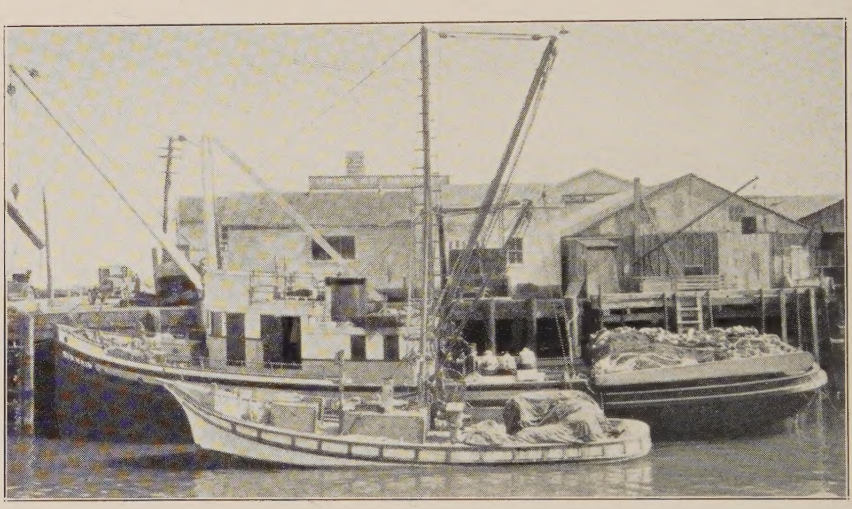

FIG. 3. A purse seine boat with a lampara launch alongside. The purse seine boat is slightly larger than the representative size used in the Monterey region for the past two seasons. The lampara launch is of representative size. The "lampara boat" fishing unit is not complete without the lighter (see Fig. 2). The lampara launches vary from 30–50 feet in length, and have engines ranging from 30–65 horsepower. The lighters that they tow are in the main from 40–50 feet in length. The purse seine boats vary in length from 55–85 feet, and have engines that range from 90–250 horsepower. (1929–1931.) Photograph by J. B. Phillips, October, 1930.

THE SIZES OF SARDINES CAUGHT BY DIFFERENT FISHING GEAR

Treatment of Data

The ring net not only replaced the lampara net, which had been used entirely on the lampara boats, but also was used on some of the purse seine boats. This section makes a general gear comparison for the two seasons under consideration, 1929–1930 and 1930–1931. Fortunately, the change from lampara to ring net on the lampara craft came during the 1929–1930 season rather than between seasons, so that comparisons between the two types of nets used on the same type of craft were possible before the lampara net was entirely displaced.

We then have the following gear comparisons for the two seasons under consideration. To avoid repetition the accompanying abbreviations are used in the comparisons. The upper case letters on the left side of the separatrix designate the type of net, and the lower case letters on the right side of the separatrix indicate the type of boat with which the net is used:

L/l = Lampara net on a lampara boat.
RN/l = Ring net on a lampara boat.
RN/ps = Ring net on a purse seine boat.
PS/ps = Purse seine on a purse seine boat.

In the above, "lampara boat" refers to a launch that ordinarily tows a barge or lighter into which the catch is loaded; "purse seine boat" refers to a boat that consistently has its catch loaded into a hold.

In analyzing the commercial sardine catch, the California State Fisheries Laboratory has used the lunar period as the basis for comparison.[3] The lunar period refers to that period from full moon to full moon. The average lunar period (L.P.) is about 29 days. For simplicity in reference, the lunar periods have been assigned consecutive numbers, dating back to the time that sampling was commenced. Lunar period dates for the two sardine seasons under consideration are as follows:

L.P.	1929–1930
121	July 22–August 20
122	August 21–September 18
123	September 19–October 18
124	October 19–November 16
125	November 17–December 16
126	December 17–January 14
127	January 15–February 13
	1930–1931
133	July 11–August 9
134	August 10–September 7
135	September 8–October 7
136	October 8–November 6
137	November 7–December 6
138	December 7–January 4
139	January 5–February 2
140	February 3–March 4

Various methods of combining the data were tested in an effort to find a method that would have adequate representation to show truly any size differences that might be present. Several factors needed to be considered. First and most important was the effect of localities upon the sizes of sardines caught. Another important factor was the limited data available. The change from lampara to ring net on the lampara boats during the 1929–1930 season was abrupt; the bulk of the changes came during lunar periods 123 and 124, thereby restricting comparisons with the lampara net mainly to these periods. Another consideration was seasonal size trends (Andrews, 1928; Clark, 1930, 1931).

An examination of the daily average trends throughout the lunar periods of the two seasons under consideration does not show any marked trend toward a consistent size at any particular portion of a period.

Inasmuch as the accuracy of comparisons by lunar periods would be reduced because of the limitations mentioned, the following method of comparison was evolved and was named "combined frequencies of same days in same localities." The manner of procedure was as follows: Only the data during the fall lunar periods were used because

[3] Commercial sardine fishing is practically always done at night. The schools of sardines are easily located during the dark moonless periods by the luminescent areas caused by their movements (Scofield, W. L., 1929).

during these periods the average sizes fluctuate the least. For the 1929–1930 season, these include the four lunar periods 122–125; for the 1930–1931 season, lunar periods 134–138. The Monterey region was then divided into the four areas shown in figure 8 (same as for

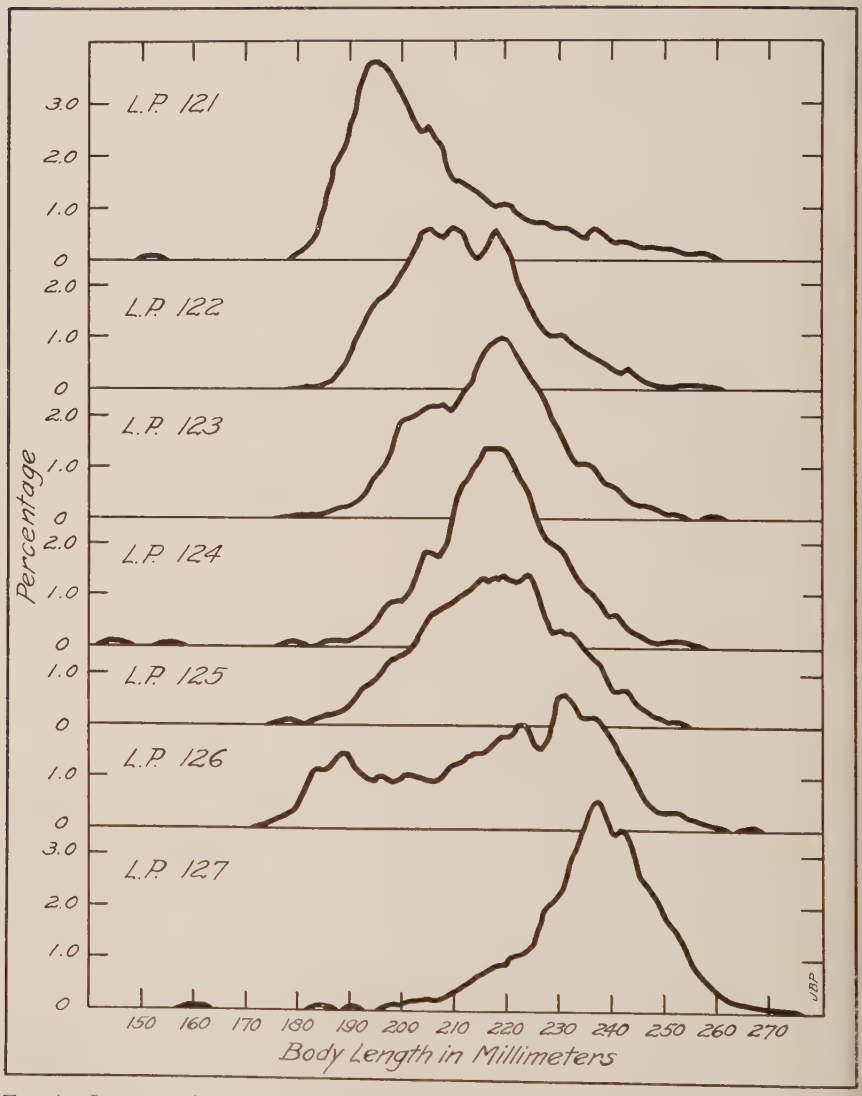

FIG. 4. Lunar period length frequencies of sardines measured at Monterey during 1929–1930 season.

locality comparisons). Any two nets were directly compared by combining the samples on the days that the two nets were represented in an area. When more than one sample appeared for a net in a day, the samples were grouped together, rather than to take the average

of two or more samples, so that the accompanying frequency curves could be presented. This accounts for the difference in number of fish making up a comparison between two nets. No segregation of males and females was made. Although there is a slight difference in size between sexes (during a season the females may average about 4 mm. greater in length), when several samples of fish are taken together the numbers of each sex usually approximate each other. The slight difference then remains fairly constant.

The basis of comparison in the method used is the average or mean length of the fish. The mode might be considered the more accurate basis to use. However, in such a complex frequency as makes up the population of the commercial sardine catch, the accuracy of the mode increases as the size of the sample increases. The limiting of the number of items used in the following comparisons, due to the factors previously explained, leaves the comparison by means as the safer and fairer method. When the number of items is restricted, the mode is often the least accurate index. In cases where the frequency curve loses its characteristic bell-shape tendency, the location of the mode becomes involved because of irregularities such as bimodal appearances. In order to check the reliability of the mean as a basis for comparison, the median of the interquartile range and the respective means or averages were contrasted for sections A, B and C of area 1 for lunar periods 122–125 for the 1929–1930 season. This comparison involved 12 cases and in all these cases the mean and the quartile median were within a millimeter of each other. In 7 of the 12 cases, the variation was under 0.5 mm.

It is true, nevertheless, that in the use of the mean as a basis of comparison, important variations that may be noted from an examination of frequency curves, are obliterated. For this reason, frequency curves accompany the tables.

1929–1930 Season

The lunar period length frequencies of sardines measured at Monterey for the 1929–1930 season are given in figure 4. The frequencies were plotted in percentage, that is, at any given length the number of fish were represented as a percentage of the total. These frequency curves of figure 4 represent total sampling of the commercial catch irrespective of gear or localities.

Figure 5 presents the frequency curves for the various gear comparisons for the season under consideration. It can be noted that the curve comparisons of graphs 1, 2 and 3 of figure 5, representing L/1, RN/1 and RN/ps comparisons, are very similar, the two curves of graph 1 being almost identical. It can further be noted that in graphs 4, 5 and 6, the curves of the PS/ps caught fish comprise in appreciable amounts more large fish than do the curves for fish caught by the other types of nets. These observations correspond to differences that show up when the means are contrasted.

Table 1 includes the following statistical values: means of the various comparisons to the nearest millimeter; the standard deviation (σ); the standard error of the mean of a sample (σ_M); the difference between the two means involved in a comparison ($M_1 - M_2$); and the

reliability of the difference between the two means [$\sigma_{(M_1 - M_2)}$]. If the difference between the means ($M_1 - M_2$) is two or more times the standard error of the difference [$\sigma_{(M_1 - M_2)}$], the difference is considered

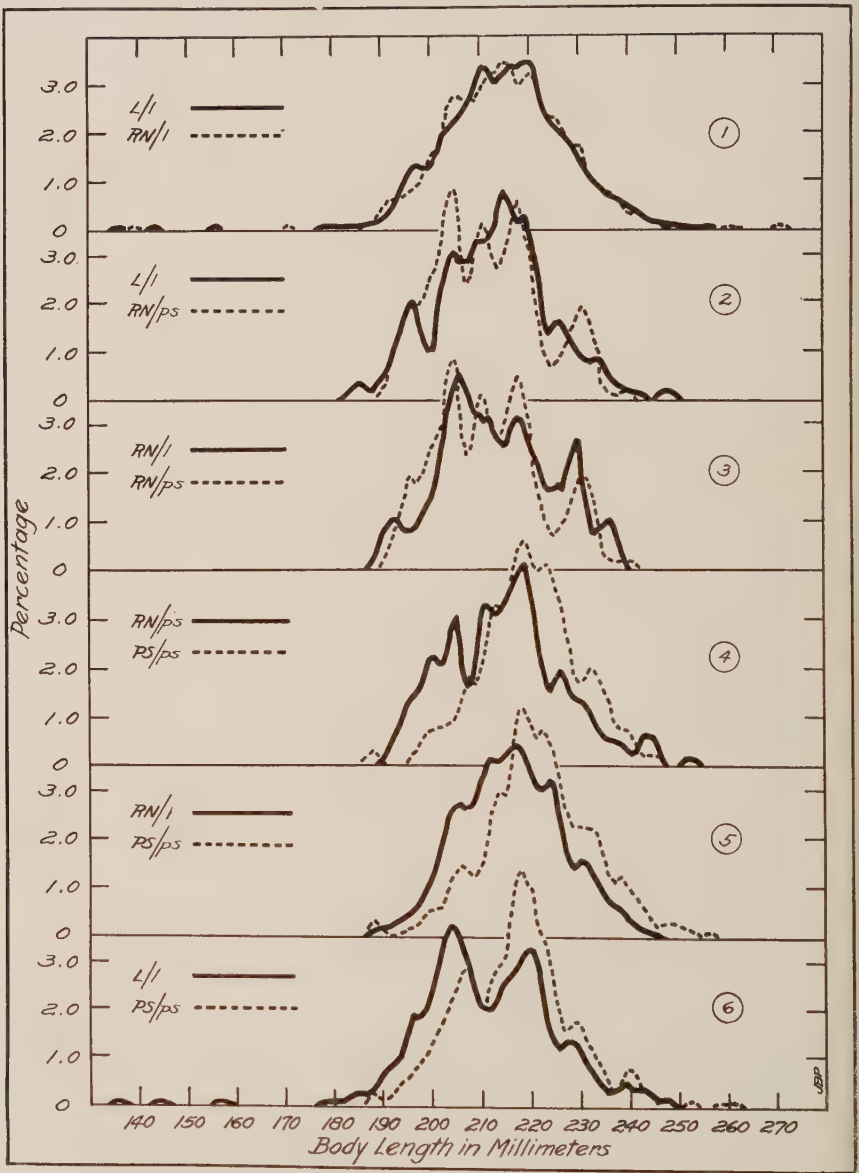

FIG. 5. Length frequency curves of the sizes of sardines caught by various types of gear in the Monterey region during the 1929–1930 season.

statistically significant. That is, the variations are almost certain to indicate significant differences in the data under investigation and can not be attributed to errors of sampling. The significant differences are marked (S).

Briefly, the various values were obtained by the following formulae:

$$\text{M or Mean} = \frac{\text{Total body length}}{\text{Number of fish}}$$

$$\sigma = \sqrt{\frac{\Sigma\ fd^2}{N} - c^2}$$

$$\sigma_M = \frac{\sigma}{\sqrt{N}}$$

$$\sigma_{(M_1 - M_2)} = \sqrt{(\sigma_{M_1})^2 + (\sigma_{M_2})^2}$$

TABLE 1

	L/l and RN/l		L/l and RN/ps		RN/l and RN/ps	
Mean (mm.)	215.22	215.30	213.04	211.92	213.87	211.92
No. fish	950	650	250	150	150	150
σ	12.52	12.45	11.14	10.56	11.20	10.56
σ_M	.41	.43	.70	.86	.91	.86
M_1-M_2	.08		1.12		1.95	
$\sigma(M_1$-$M_2)$	.59		1.11		1.25	

	PS/ps and RN/ps		RN/l and PS/ps		PS/ps and L/l	
Mean (mm.)	219.78	214.90	215.92	221.28	216.61	211.56
No. fish	200	200	500	300	250	350
σ	10.03	11.90	10.74	10.13	11.27	14.38
σ_M	.71	.84	.48	.58	.71	.77
M_1-M_2	4.88 (S)		5.36 (S)		5.05 (S)	
$\sigma(M_1$-$M_2)$	1.10		.75		1.05	

Summary of mean comparisons:

L/l equal RN/l
L/l greater than RN/ps by 1 mm.
RN/l greater than RN/ps by 2 mm.
PS/ps greater than RN/ps by 5 mm. (S)
PS/ps greater than RN/l by 5 mm. (S)
PS/ps greater than L/l by 5 mm. (S)

Comparisons of means as given in table 1 show that the PS/ps caught fish averaged larger in size than fish caught by the other types of nets by 5 mm., the L/l and RN/l caught fish averaged the same in size and the RN/ps caught fish averaged the smallest in size. In comparing the difference between the means and the reliability of the difference between the two means, only the PS/ps differences are found to be significant. Statistically, this shows that the PS/ps caught fish averaged larger in size than the fish caught by the other types of nets, the other types of nets catching fish of about the same sizes.

During the 1929–1930 sardine season, therefore, the fish caught by the PS/ps gear averaged significantly larger, by 5 mm., than fish caught by the other types of gear, namely, L/l, RN/l and RN/ps.

The L/l, RN/l and RN/ps took fish of about the same average size.

1930–1931 Season

The L/l gear was not present in the 1930–1931 season.

Lunar period length frequencies of sardines measured at Monterey for the 1930–1931 season are presented in figure 6. These frequency

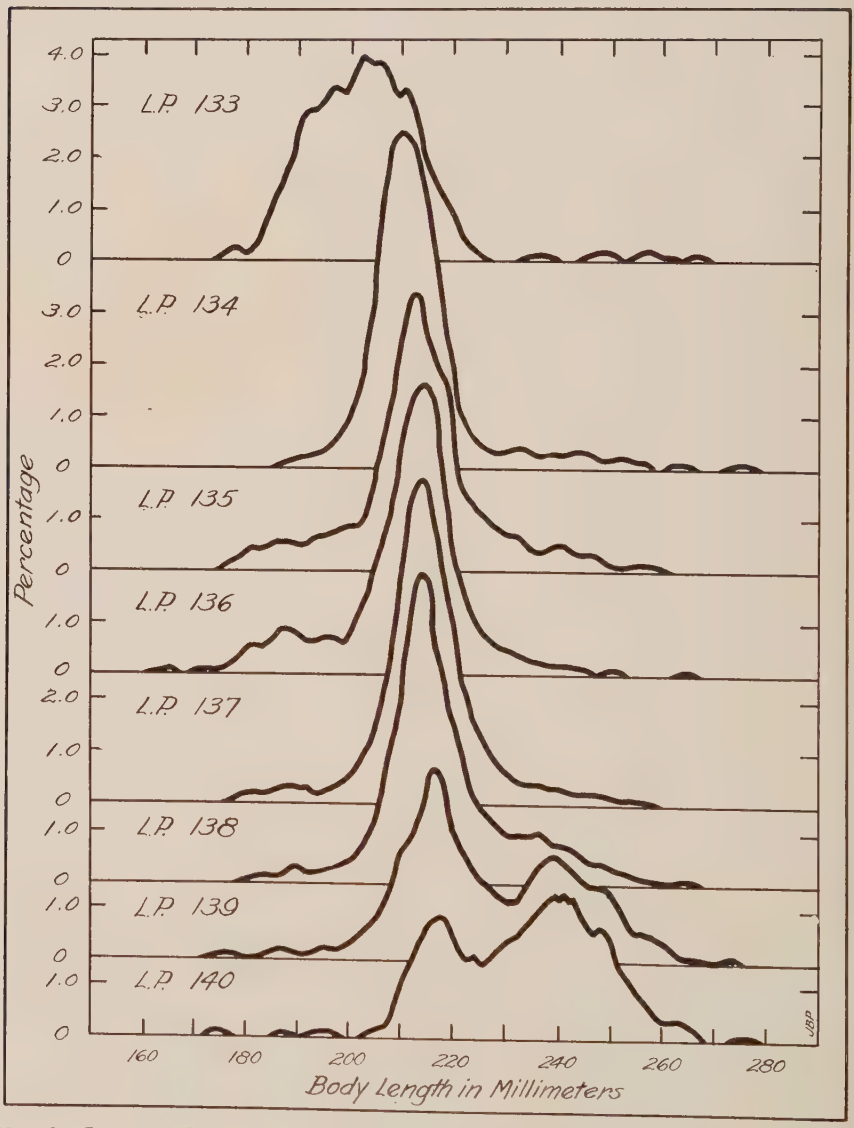

FIG. 6. Lunar period length frequencies of sardines measured at Monterey during 1930–1931 season.

curves represent total sampling of the commercial catch irrespective of gear or localities.

Figure 7 offers the frequency curves for the various gear comparisons for the season under consideration. The apparent similarity

of the curve comparisons in the graphs leads one to conclude that during this season the various types of nets caught fish of about the same sizes. In a statistical comparison of the mean differences, only the curves of graph 2 are similar, the curves of graphs 1 and 3 being significantly different.

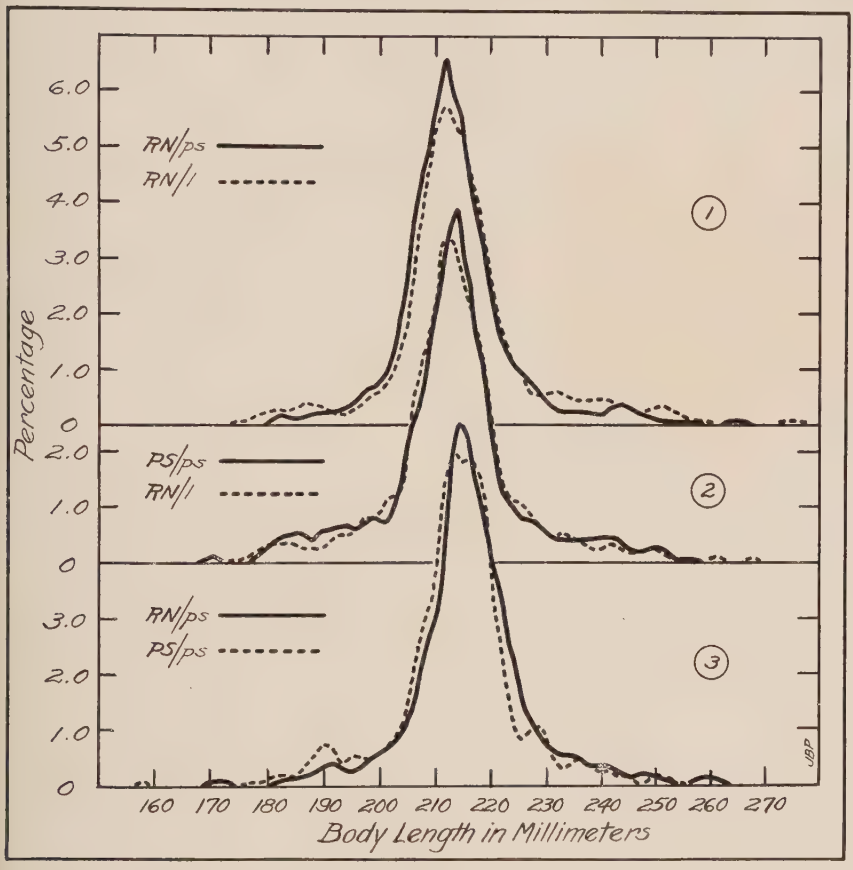

FIG. 7. Length frequency curves of the sizes of sardines caught by various types of gear in the Monterey region during the 1930–1931 season.

In table 2 are included the same statistical data for the 1930-1931 season as those in table 1 for the 1929–1930 season.

TABLE 2

	RN/l and PS/ps		RN/l and RN/ps		PS/ps and RN/ps	
Mean (mm.)	213.13	212.77	214.51	213.32	212.55	214.60
No. fish	650	350	1300	1100	750	1000
σ	11.99	13.50	12.40	10.14	10.77	9.87
σ_M	.47	.72	.34	.31	.39	.31
M_1-M_2	.36		1.19 (S)		2.05 (S)	
$\sigma(M_1-M_2)$	.86		.46		.50	

Summary of mean comparisons:

RN/l equal PS/ps
RN/l greater than RN/ps by 2 mm. (S)
RN/ps greater than PS/ps by 2 mm. (S)

From the comparisons of means shown in table 2, the following results are apparent: Fish caught by RN/ps averaged significantly

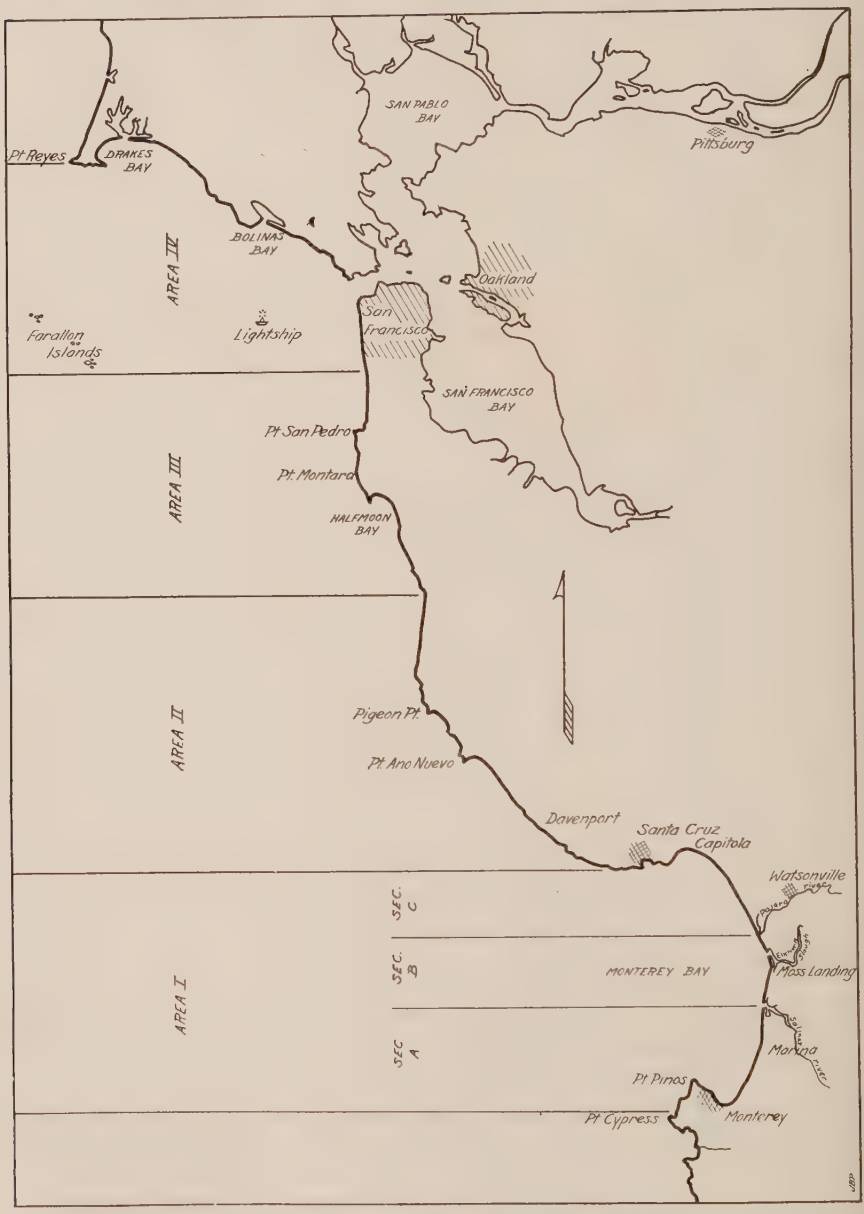

FIG. 8. Map of fishing areas covered by fishing boats supplying the Monterey sardine plants. The areas I–IV are collectively known as the "Monterey region" in this report, although a plant at Pittsburg is supplied by boats fishing in area IV.

larger than PS/ps fish; fish caught by RN/l averaged significantly larger than RN/ps fish. Yet, the RN/l and PS/ps caught fish are of the same average size. Obviously the results are inconsistent.

During the 1930–1931 sardine season, there was no consistent average size difference in fish caught by the various types of nets.

1929–1930 and 1930-1931 Seasons Contrasted

In contrasting the results of the two seasons under consideration, we find that the results of the gear comparisons contradict themselves. Briefly, the results for the 1929–1930 season show the PS/ps caught fish averaged significantly larger than fish caught by the other types of gear, namely L/l, RN/l and RN/ps. Amongst themselves these three types of gear caught fish whose average lengths were not significantly different. The results for the 1930–1931 season show no significant difference in the average sizes of fish caught by the RN/l and PS/ps, but the RN/ps fish averaged significantly larger than the PS/ps fish, and the RN/l caught fish averaged significantly larger than the RN/ps caught fish. Although the mean differences for the 1930–1931 season are smaller than the differences for the 1929–1930 season, by examination of figures 4 and 6, the presence of a prominent mode for the 1930–1931 season will be noted. Due to this concentration, the differences are more significant for the 1930–1931 season than the figures actually indicate.

Structural differences in the various types of nets do not suggest any reasons why sizes of fish caught by these gear should differ. As for the minimum size of mesh in the landing bags of the various types of nets, there is no appreciable difference. Although the purse seine mesh is slightly larger when new, the tarring process to which the net is subjected reduces the size of mesh practically to the same size as that of the tanned ring and lampara nets.

There was evidently no size selection exhibited by the lampara, ring or purse nets in the Monterey region during the 1929–1930 and 1930–1931 sardine seasons. The sizes of sardines caught depended upon the sizes of fish that happened to be present in the localities fished.

THE SIZES OF SARDINES CAUGHT IN DIFFERENT LOCALITIES

Treatment of Data

The expansion of the fishing grounds northward in the Monterey region has led to the question of whether there is a difference in the average sizes of sardines caught in the various localities. As mentioned, the expansion of fishing grounds has been to the northward from Monterey to Point Reyes. To effect a comparison of localities, the Monterey region from Point Cypress to Point Reyes was divided into four areas as shown in figure 8. Area I includes Monterey Bay and those waters between a line due west from Point Cypress on the south and Point Santa Cruz on the north; area II to a line due west from a point about midway between Pigeon Point and Pillar Point; area III to a line due west from South San Francisco; and area IV to a line due west from Point Reyes. No distinction is made as to distance of the catches from shore. No catches have been reported more than 15 miles offshore except in area IV. In area IV, the catches can be expected anywhere within the South San Francisco-Farallon Islands-Point Reyes triangle. The Farallon Islands are located approximately 20 miles south of Point Reyes and 25 miles west of South San Francisco.

For comparison within itself, area I was subdivided into sections A, B and C. Section A commences with the southern boundary of area I and extends to a line due west of the Salinas River; section B to a line due west of the Pajaro River; and section C to the northern boundary of area I.

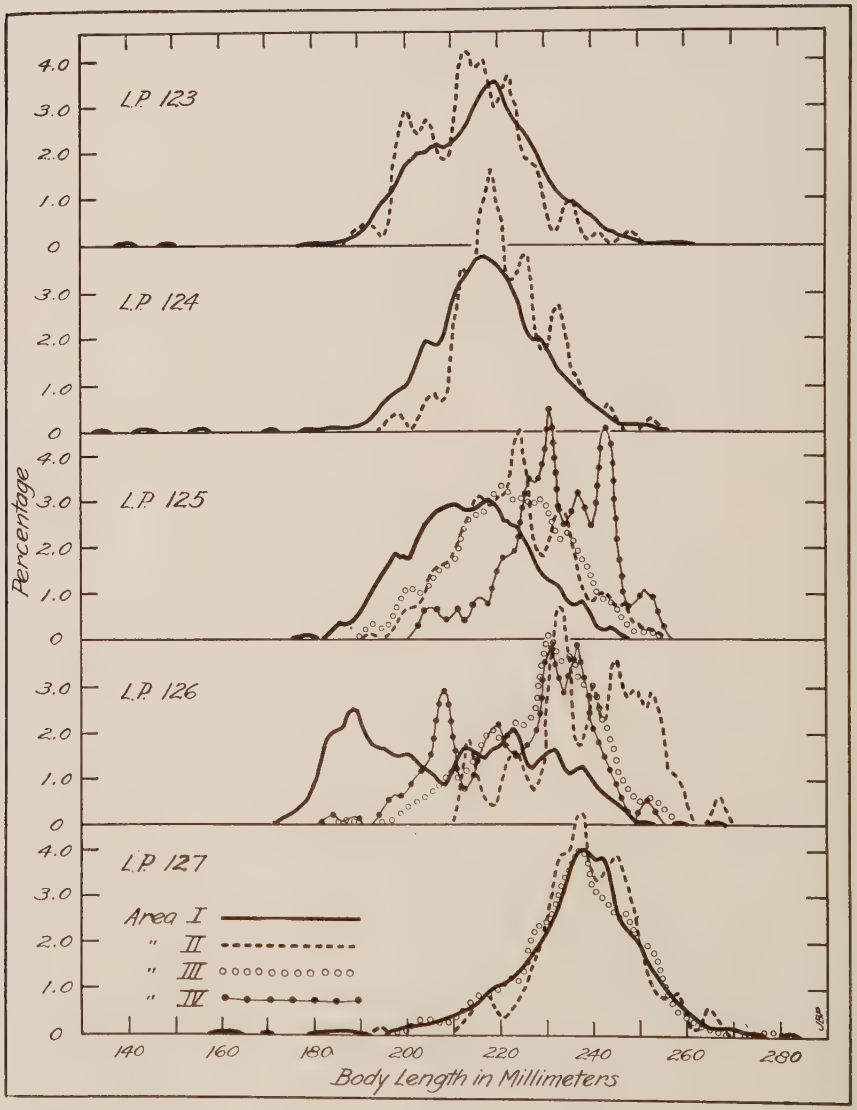

FIG. 9. Length frequency curves of the sizes of sardines caught in the different areas of the Monterey region during the 1929–1930 season. Lunar periods 121 and 122 are omitted.

1929–1930 Season

Comparison of Areas I–IV

The following area comparisons represent by lunar periods all of the sample frequencies. In figure 9 are offered the lunar period fre-

quency curves for areas I–IV. These frequencies are in percentages as are all the other frequencies. Lunar periods 121 and 122 were omitted because of lack of comparisons with area I. This also coincides with the comparable lunar periods offered for the 1930–1931 season.

The means for the lunar period frequencies of areas I–IV are pictured in figure 10. These values are given in table 3, together with the number of fish represented by the mean or average.

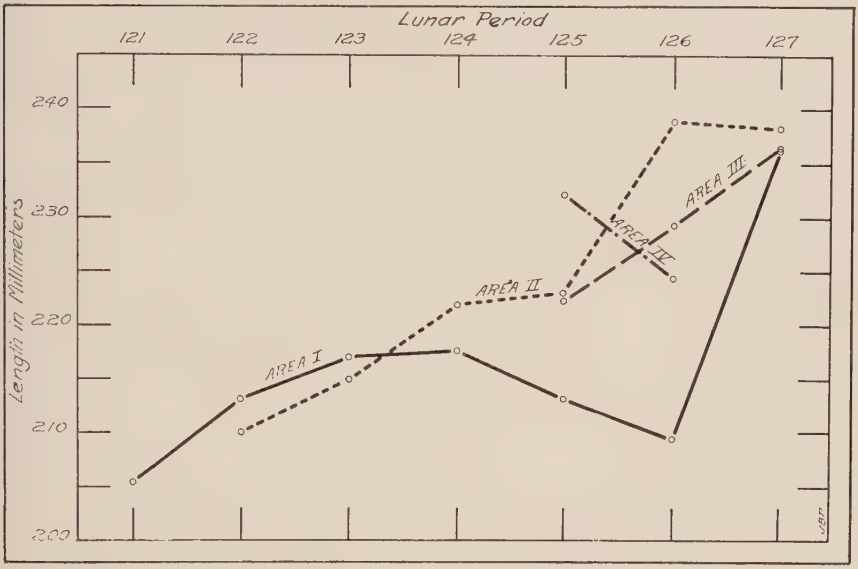

FIG. 10. Lunar period means, or average body lengths, of sardines caught in the different areas in the Monterey region during the 1929–1930 season.

TABLE 3

Lunar period	Area I		Area II		Area III		Area IV	
	No. fish	Mean	No. fish	Mean	No. fish	Mean	No. fish	Mean
121	1000	205.6						
122	1550	213.3	150	209.9				
123	1400	217.1	100	215.1				
124	1400	217.8	100	222.2				
125	750	213.6	250	223.2	200	222.3	50	232.4
126	850	209.7	50	239.2	450	229.5	150	224.7
127	1050	236.5	150	238.6	550	236.7		

With the demand remaining fairly constant, the scarcity of sardines in area I, or Monterey Bay, is indicated by the extension and intensity of fishing efforts in the other areas. Area IV seemed to be reliable at all times. However, because of time and expense involved, area IV was only fished when the other areas failed to satisfy the demand. The sardines in these waters are not very "wild" and large schools can be taken without much danger of splitting nets.

Comparing the means of the areas throughout the lunar periods represented, we find in area I an increase to lunar period 124, lunar periods 125 and 126 show decreases, and lunar period 127 a decided

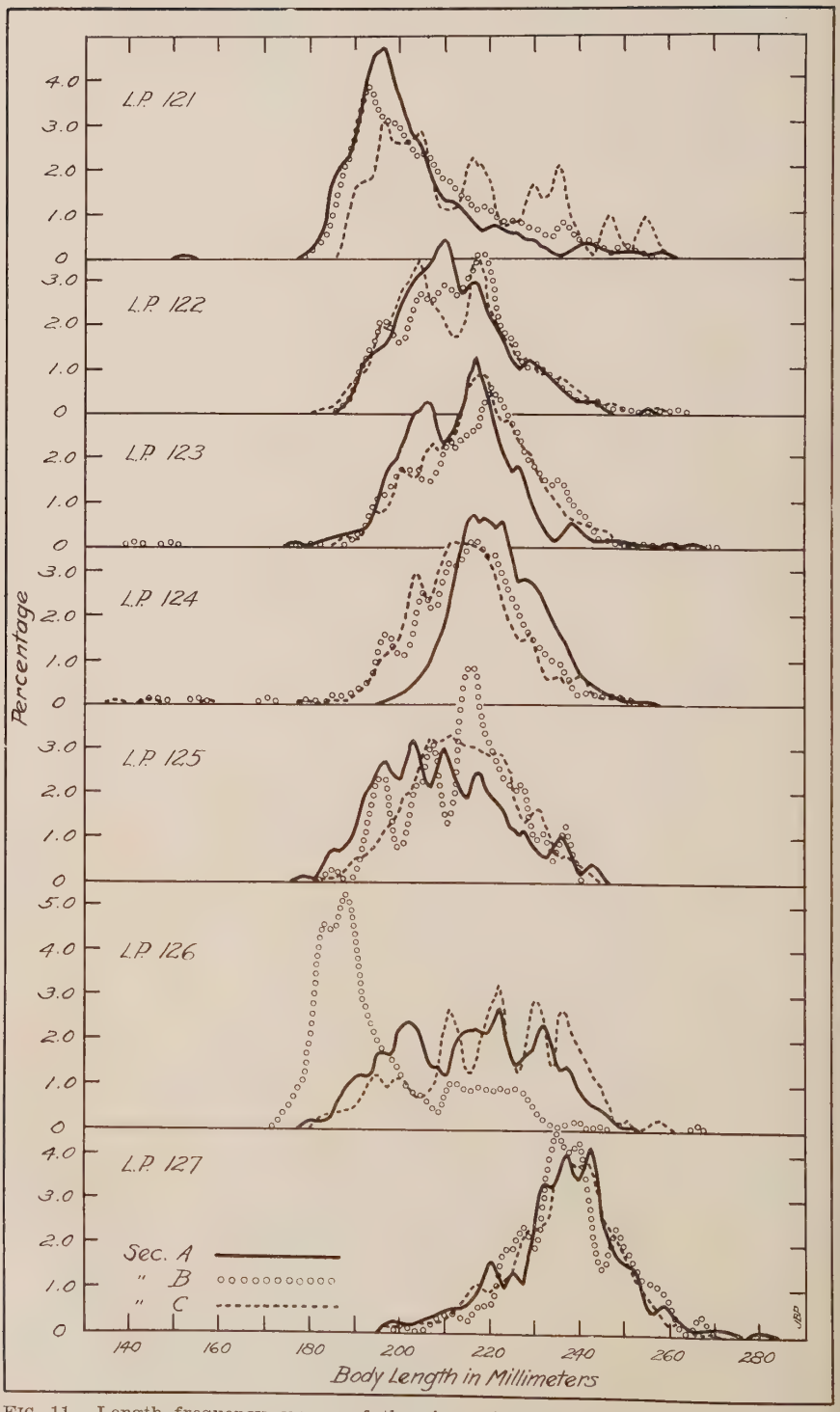

FIG. 11. Length frequency curves of the sizes of sardines caught in the different sections of area I of the Monterey region during the 1929–1930 season.

increase. The decrease in size during lunar periods 125 and 126 indicates the catching of smaller sized fish that were probably present in Monterey Bay throughout the fall fishery, but their presence was not felt in the catch until the disappearance of the larger sized fish. The decided increase in the average size taken in the last lunar period (127) was due to the appearance of the very large winter fish, an annual occurrence. These large winter fish prevailed in areas I, II and III at about the same lunar period, as may be deducted from an examination of figures 9 and 10. The greater variation of area II may have been due to the lesser number of fish making up the average.

Areas II and III show an increase in average sizes throughout the lunar periods represented, except for a slight drop for area II in the last lunar period. The rather high average for area II in lunar period 126 is based on just one sample of fish. Area IV, on the other hand, shows a decrease in the average sizes of fish caught in lunar periods 125 and 126. Examination of frequency curves (Fig. 9) shows that area IV yielded a greater percentage of larger fish for lunar period 125. For lunar period 126 the range of sizes was practically the same as for area III, except that a higher percentage of smaller sized fish brought a decrease in the average size. However, too few samples are represented in area IV to make the comparisons adequate at the present time.

Comparing the lunar periods 125 and 126 when catches are represented in all the areas, we find that area II yielded the largest fish most times, then area IV, III and I in the order named.

Area I

Figure 11 presents the frequency curves for the three sections of area I, or Monterey Bay, throughout the season. Table 4 includes the corresponding means together with the number of fish represented by the samples. The means of table 4 are pictured in figure 12.

TABLE 4

Lunar period	Section A		Section B		Section C		Area I	
	No. fish	Mean	No. fish	Mean	No. fish	Mean	No. fish	Mean
121	400	202.2	500	206.3	100	215.2	1000	205.6
122	650	212.8	550	213.9	350	213.3	1550	213.3
123	350	213.5	600	218.7	450	217.6	1400	217.1
124	500	222.7	300	215.5	600	214.8	1400	217.8
125	250	210.4	100	214.8	400	215.2	750	213.6
126	250	215.8	350	196.5	250	222.0	850	209.7
127	300	236.4	200	238.3	550	236.0	1050	236.5

In a comparison of the means by lunar periods on the basis of a mean being equal to, or greater than, the means of either of the other two sections, we have the following results:

Section A predominates 1 time.
Section B predominates 3 times.
Section C predominates 3 times.

The pronounced drop of the mean for section B, in contrast to the means of the other two sections, during lunar period 126 may be

explained by the following: The small fish may have also been present in sections A and C. The bulk of the small fish from section B was taken on the last sample day of the lunar period, just before the full moon; hauls were made just before daybreak.

In order to get to section B, the fishing boats have to go through section A. The small fish may have been passed up in section A. Upon arriving in section B, with time growing shorter, the crews chanced the acceptance of the small fish by the canneries and caught them, rather than return without a load. Some of the canneries accepted these small fish and others rejected them. However, all crews were warned against bringing in the smaller sardines in the future.

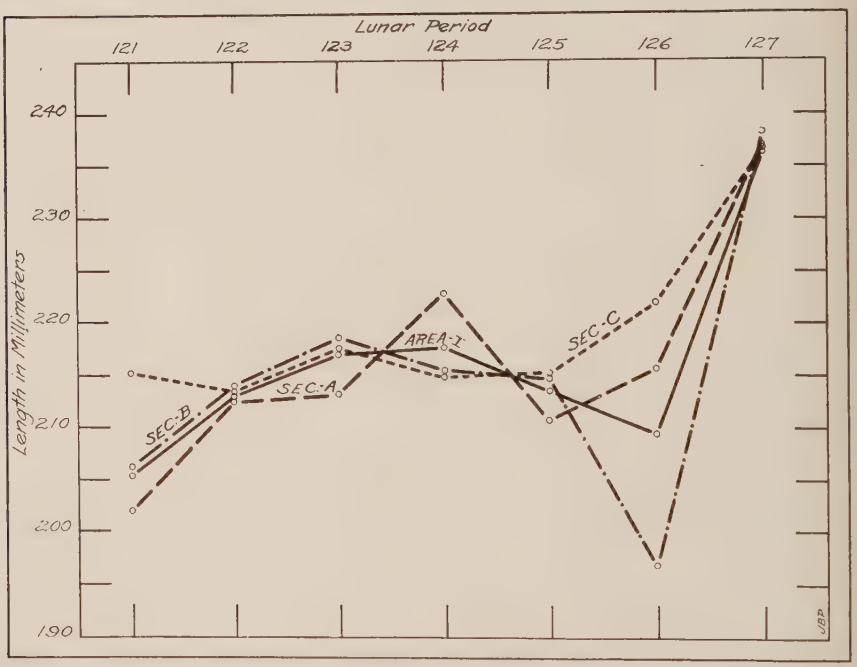

FIG. 12. Lunar period means, or average body lengths, of sardines caught in the different sections of area I in the Monterey region during the 1929–1930 season.

As was noted for the area comparisons, lunar period 127 found the large winter fish predominating in all the sections. (Figs. 11 and 12.)

1930–1931 Season

Comparison of Areas I–IV

The following area comparisons represent, by lunar periods, all of the sample frequencies taken in the areas. In figure 13 are represented the lunar period frequency diagrams for areas I–IV. These frequencies are in percentages. Lunar periods 133 and 134 were omitted because of lack of comparisons with area I. This also coincides with the comparable lunar periods offered for the 1929–1930 season.

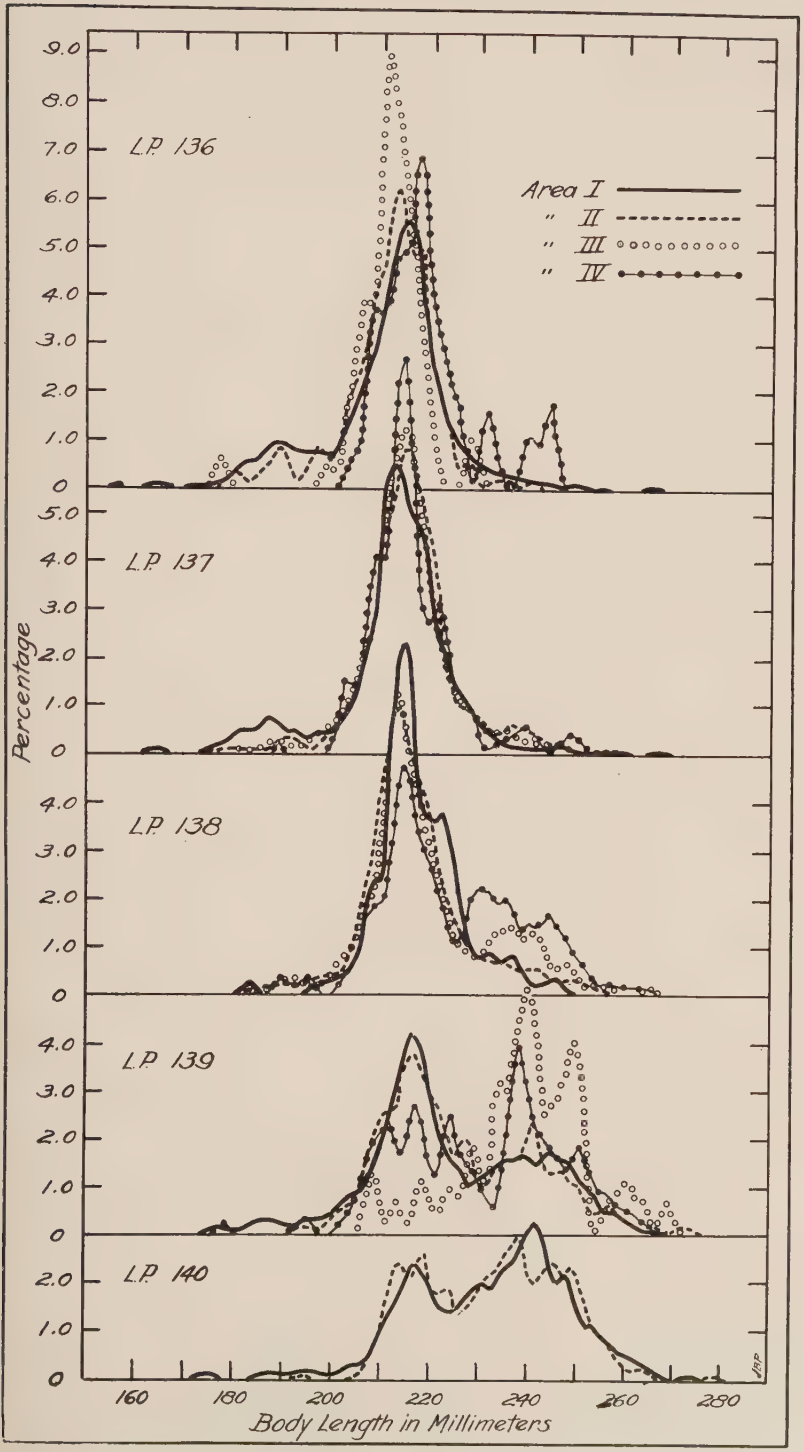

FIG. 13. Length frequency curves of the sizes of sardines caught in the different areas of the Monterey region during the 1930–1931 season. Lunar periods 133–135 are omitted.

The means for the lunar period frequencies of areas I–IV are pictured in figure 14. These values together with the number of fish represented by the average are shown in table 5.

TABLE 5

Lunar period	Area I		Area II		Area III		Area IV	
	No. fish	Mean	No. fish	Mean	No. fish	Mean	No. fish	Mean
133	500	203.1						
134	1750	213.4						
135	1400	214.9	100	202.4				
136	1700	210.7	150	210.7	50	210.8	50	218.6
137	500	212.4	550	215.8	550	215.0	100	215.3
138	150	217.5	1000	216.5	350	219.2	200	224.4
139	650	224.8	400	226.2	50	239.6	150	230.1
140	600	232.9	400	233.0				

The scarcity of sardines in Monterey Bay (area I) is indicated by the catches being made in the other areas. Although the 1930–1931 season was affected economically by a depressed market, the evidence

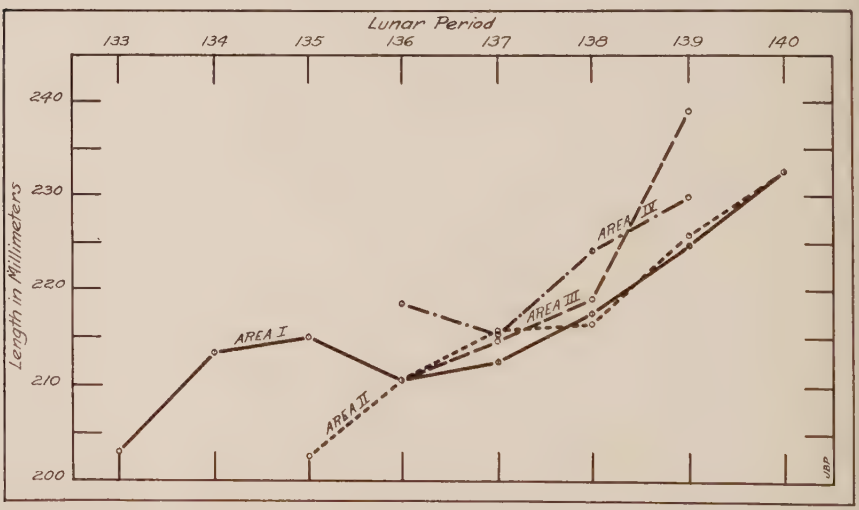

FIG. 14. Lunar period means, or average body lengths, of sardines caught in the different areas in the Monterey region during the 1930–1931 season.

remains that the northern regions were more intensively fished than they were during the 1929–1930 season.

In area I the drop in average sizes came with lunar period 136, earlier than for the 1929–1930 season. Beginning with lunar period 136, there is a steady increase in average sizes of fish caught in area I. Except for the smaller average size of fish caught during lunar period 135, the average sizes of sardines caught in area II did not vary decidedly from those taken in area I. During lunar periods 136–139, the fish caught in areas III and IV are for the most part of greater average sizes than those taken in areas I and II.

Comparing the lunar periods (136–139) when catches are represented in all the areas, we find that there was a progressive increase

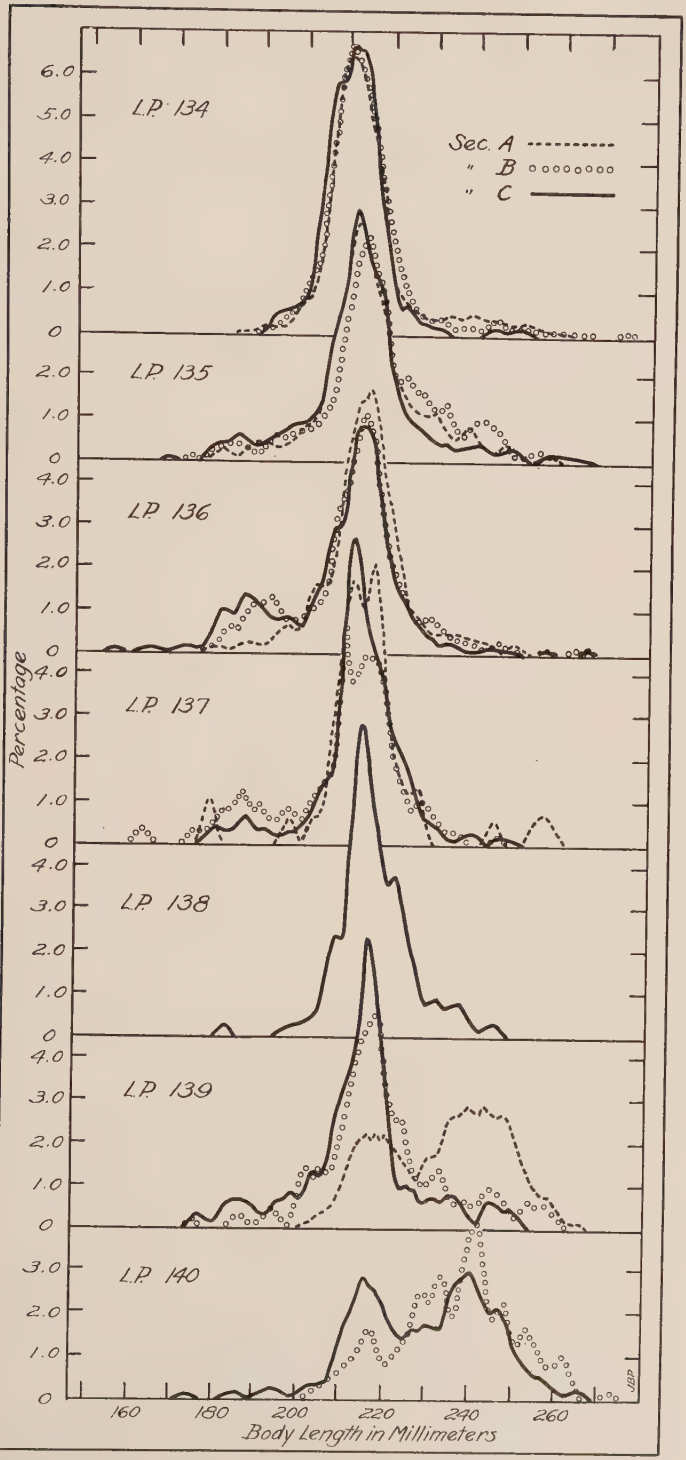

FIG. 15. Length frequency curves of the sizes of sardines caught in the different sections of area I of the Monterey region during the 1930–1931 season.

in average sizes of fish in the areas northward, with area IV yielding fish of the largest average sizes during the greater number of lunar periods.

From figure 13, it can be observed that the first trace of the large winter fish is evident in area IV during lunar period 136. In lunar period 138 they appeared in still stronger numbers in this same area. During lunar period 139 they were apparent in all the areas. Throughout lunar period 140 these fish prevailed in about equal numbers in areas I and II, the only two areas represented at the close of the season.

Area I

The frequency curves for the three sections of area I throughout the season are shown in figure 15. The corresponding means together with the number of fish represented by the samples are given in table 6. The means of table 6 are shown in figure 16.

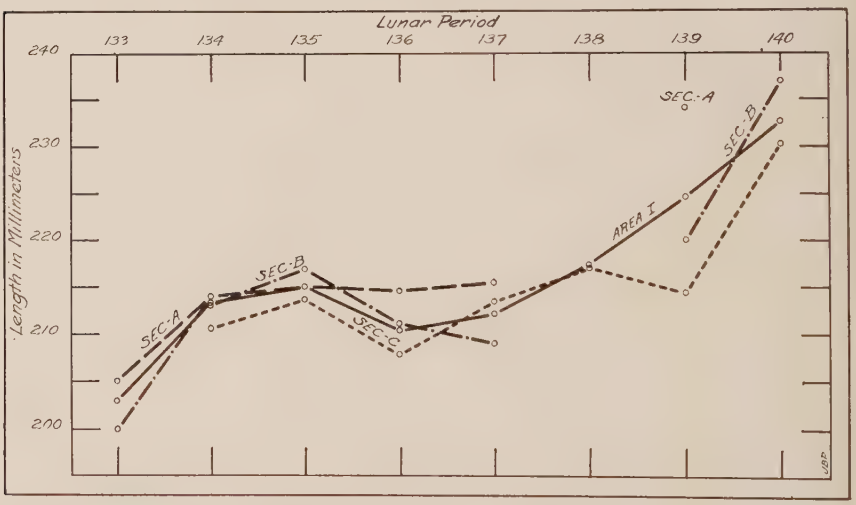

FIG. 16. Lunar period means, or average body lengths, of sardines caught in the different sections of area I in the Monterey region during the 1930–1931 season.

TABLE 6

Lunar period	Section A		Section B		Section C		Area I	
	No. fish	Mean	No. fish	Mean	No. fish	Mean	No. fish	Mean
133	300	205.0	200	200.1			500	203.1
134	950	214.0	600	213.3	200	210.8	1750	213.4
135	350	215.0	350	217.0	700	213.8	1400	214.9
136	450	214.6	500	211.2	750	208.0	1700	210.7
137	50	215.4	150	209.4	300	213.4	500	212.4
138					150	217.5	150	217.5
139	300	233.9	150	220.3	200	214.4	650	224.8
140			200	237.6	400	230.5	600	232.9

In a comparison of means by lunar periods on the basis of a mean being equal to, or greater than, the means of either of the other two sections, the following results are obtained:

Section A predominates 3 times.
Section B predominates 1 time.
Section C predominates 0 times.

This is in direct contrast to the 1929–1930 season when section A averaged the smallest fish for the greater number of lunar periods.

From examination of figure 15, it can be observed that the large winter fish coming into area I, first made their appearance in section A during lunar period 139. These fish would normally be first expected in sections C and B inasmuch as the winter fish were first noticeable in the northern areas. In the final lunar period (140) of the season, no catches are represented in section A, and section B had a greater percentage of the large fish than section C.

1929–1930 and 1930–1931 Seasons Contrasted

During the lunar periods when catches are represented in all areas, data for the 1929–1930 season indicate that area II yielded fish of the largest average sizes, then areas IV, III and I, in the order named. The data for the 1930–1931 season indicate a progressive increase in average sizes of fish northward from area I to area IV. The limited data available at present warrant only general conclusions: that area I yielded fish of the smallest average sizes during the later lunar periods when the other areas were yielding fish of larger average sizes. Examination of figures 10 and 14 will show area I to yield fish of larger average sizes than area II during the early fall lunar periods.

A comparison of the frequency curves of the catches of the areas for the two seasons (Figs. 9 and 13) indicates that the large winter fish were first evident in numbers in area IV. Since data include only two seasons, we can not state definitely that these fish normally appeared in area IV first. The trend of the large winter fish is apparently southward.[4] The areas represented at the close of the seasons yielded fish of about the same average sizes.

Division of area I, or Monterey Bay, into sections A, B and C (southern, central and northern) shows that in a comparison by lunar periods section A yielded fish of the smallest average sizes for the 1929–1930 season and fish of the largest average sizes for the 1930–1931 season. From the results of the two seasons under consideration, we can not expect to find, over a period of time, any difference in the average sizes of sardines caught from the northern, central or southern sections of area I, or Monterey Bay.

SUMMARY

The results of this study based upon data collected in 1929–1930 and 1930–1931 are:

1. The sizes of sardines caught by lampara, purse seine and ring net gear of present construction depend upon the sizes of fish available to the fishermen and can not be attributed to a size selection resulting from type of gear.

2. Comparisons of the northern, central and southern sections of Monterey Bay show that the average sizes of the fish from one section

[4] This suggests a southward spawning movement of the sardine population along the California coast.

are not consistently smaller or larger than the average sizes of fish taken in any of the other sections.

3. Large winter fish are first taken in area IV, the most northward area in the Monterey region. These fish appear to spread southward through the Monterey region. At the close of the fishing season, in February, fish of the same general large sizes were taken in all of the areas in which there was fishing.

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THE EFFECT OF GEAR AND LOCALITY ON THE SIZES OF SARDINES TAKEN IN THE LOS ANGELES HARBOR REGION[5]

By G. H. Clark

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STATEMENT OF PROBLEM

Changes which occur in a fishery, whether in the gear, method of fishing, locality of catches, or from any other source should be noted, and their effect on any scientific investigation of the fishery should be determined. Several very marked changes have occurred in the San Pedro sardine fishery since 1919, at which time the California Division of Fish and Game first undertook the study of the California sardine (*Sardina caerulea*). Up to and including 1924, little if any change occurred in the fishery, which was carried on by small boats using lampara or round haul nets in waters close to the mainland and not far from their home ports (vicinity of Los Angeles Harbor). From 1925 to the present time (1931) two major changes have occurred which affected both the industry and the sardine investigation. First, the introduction of purse seine boats and purse seines in the fishery has brought about an extension of the fishing grounds, increased the boat catches, and influenced the enlargement of cannery capacity. Second, most of the lampara nets were remade into ring nets, so that by 1930 all sardine fishing was done either by purse seines or ring nets. This latter movement increased the efficiency of sardine gear.

Since these new methods are at present firmly established, this study was undertaken to determine the effect of these changes on the sampling system and on the entire investigation of the California sardine conducted by the California State Fisheries Laboratory since 1919.

[5] Contribution No. 114 from the California State Fisheries Laboratory.

For the past number of years, the sardine catch has been sampled semiweekly at San Pedro. Each half-week, samples of 50 fish each are taken at random from the catches of five different boats. At the same time the captain of each fishing boat is questioned as to the location of catch, time of each haul, and the amount taken. The name of the boat, type of gear used, and the name of the cannery to which the fish are delivered, are also secured. No attempt has been made to sample just one type of gear or fish taken in any restricted area within the fishing region, but the plan has always been to make the sampling as representative of the commercial catch as possible.

Because of the changes in fishing apparatus and the extension of fishing grounds, we are now confronted with the questions: Is our sampling system adequate at the present time, and are the present data comparable with data collected in earlier years? For example, did the lampara nets take the same sized fish as the purse seines or was there a selection on the part of one or the other? Do purse seines and ring nets catch the same sizes of sardines? If the sizes of sardines taken by these three types of gear are not about the same, a new sampling policy should be planned and adopted.

The same questions apply to the sizes of fish taken in the different fishing areas within the San Pedro region. If the sizes of sardines in these various areas are unlike, then some adjustment of the sampling system should be made. It is to answer these questions that this report has been prepared. First, do the different kinds of nets used in the sardine fishery at San Pedro consistently catch different sizes of sardines? Second, are different sizes of sardines taken in the three main fishing areas within the San Pedro fishing region?

FISHING AREAS CONSIDERED

In the San Pedro fishing district there are three main areas, in which most of the fishing is done (Fig. 17):

1. Mainland area, from Oceanside on the south to Point Dume on the north, including the waters out to Catalina Island.

2. Northern island area, including the waters from Point Dume westward to and around the islands of Santa Cruz, Santa Rosa, San Miguel, and Anacapa.

3. Southern island area, comprising the waters outside the mainland and northern island sections, including the waters adjacent to San Clemente, San Nicolas and Santa Barbara islands and outside Catalina Island.

In the early days of sardine fishing, fishermen concentrated their activities in the mainland area, but since 1925, the fishing region has been extended to include the northern and southern island areas.

SOURCE OF MATERIAL

The material for this study has been taken from the samples of sardines collected during the 1925–1926 to 1930–1931 seasons, inclusive. Data for the comparisons of the purse seines and lampara nets were available only for two seasons, 1925–1926 and 1926–1927, and the material for the comparison of purse seines and ring nets was available for three seasons, 1928–1929, 1929–1930 and 1930–1931. The data

used in comparing sizes of fish taken in the three areas were available for all five seasons from 1925–1926 to 1930–1931, inclusive, although the last season was very poor for area comparison.

INFLUENCING FACTORS ON THE SIZES OF SARDINES

The construction, size and operation of lamparas, purse seines and ring nets are fully described in other publications (Fry, 1931; Higgins and Holmes, 1921; Scofield, N. B., 1924; Scofield, W. L., 1926.1, 1929; Skogsberg, 1925), so it is not necessary to discuss these subjects in this report. We are primarily interested in whether the three types of gear select different sized sardines, and whether different sized fish are caught in the three fishing areas as described above.

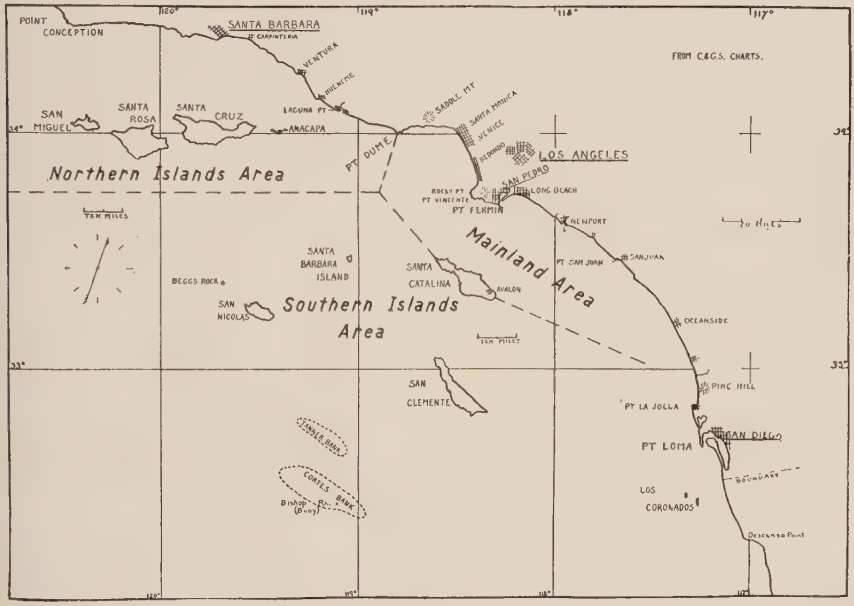

FIG 17. Map of the Los Angeles Harbor sardine fishing region showing the three areas in which catches were made.

There are four factors which have been known to influence the sizes of sardines caught:

1. Sardines average larger during the light of the moon than during the dark of the moon (Scofield, W. L., 1926.2); that is, sardines average larger at the beginning and end of each lunar period than during the middle of the lunar month.

2. Sardines taken in the early part of the night and the last part of the night are larger than those caught during the middle of the night (Scofield, W. L., 1926.2).

3. Small sardines are taken by the commercial fishermen in the fall and large sardines are caught in the winter (Clark, 1930).

4. Different dominant size-groups of sardines appearing in the commercial catch in various seasons influence the average sizes of sardines according to the size of the dominant group (Clark, 1931.)

The first two facts have been demonstrated in the case of the Monterey fishery, but they do not hold true for every lunar month or for each night. These two facts have never been shown for the sardines in the San Pedro fishery, and it is doubtful whether they could be proven for this region. An examination of the average sizes of sardines in the first two seasons (1919–1920 and 1920–1921) sampled by days and in the later years by semiweekly periods gives only a slight indication in some cases that smaller sardines are caught in the dark of the moon. There is no evidence to show that larger fish are taken at the beginning and at the end of each night's fishing in the San Pedro locality.

Nevertheless, since the above two factors may have some influence on the sizes of sardines, comparisons of the sizes caught by days were not used, but instead every effort was made to compare as large a time interval as possible so that the data may still be reasonably comparable, and in addition to utilize the maximum amount of data available for each comparison.

During the fall in November and part or all of December, the small, fall sardines comprise the commercial catch. Some time in the latter part of December or in January—the time varies as much as a month for different seasons—the San Pedro commercial catch begins to include large sized winter sardines. This change of size (transition) of fish in a region is apparently due to the movement of the large fish into the region in great numbers, thus masking the presence of the small fish. The lunar month in which this size-transition occurs is termed in this paper, the "transition period."

Because of the transition of sizes of sardines and the presence in the catch of different dominant age-groups, no attempt could be made to compare seasonal average sizes of sardines either for gear or for areas, but instead comparisons between lunar months were employed.

The four factors just outlined add complications to this study of the effect of the gear and area changes on the sardine sampling system. However, the outstanding factor is the transition of the size of fish which will be referred to frequently in the later discussion. The other three facts have been eliminated by the treatment of the data. Accordingly, all comparisons, except in some instances of deviations, were made by lunar months whether they were by means, deviations or frequencies.

COMPARISON OF SIZES OF SARDINES BY GEAR

Purse Seine and Lampara

Since there might be differences between the sizes of sardines from the three fishing areas, each gear comparison is made within each area of the fishing district. This eliminates the possibility of one area influencing the size of fish taken by any particular gear, even though the amount of data for each comparison is materially diminished.

Because 1925–1926 and 1926–1927 are the only seasons for which a comparison of the purse seine and lampara caught fish could be made, the data are rather scanty. However, the material affords a contrast

of the sizes of fish taken by the two types of gear in the three fishing areas, *i.e.*, northern island, southern island and the mainland. Figure 18A and table 7A show by lunar months the average lengths of fish taken by each type of gear during the 1925–1926 season. It will be noticed that out of the six comparisons, the sizes of the purse seine caught fish exceed those of the lampara net fish in five cases. In addition, there is an instance when the average lengths of the lampara net fish are extremely small, although there are no purse seine caught

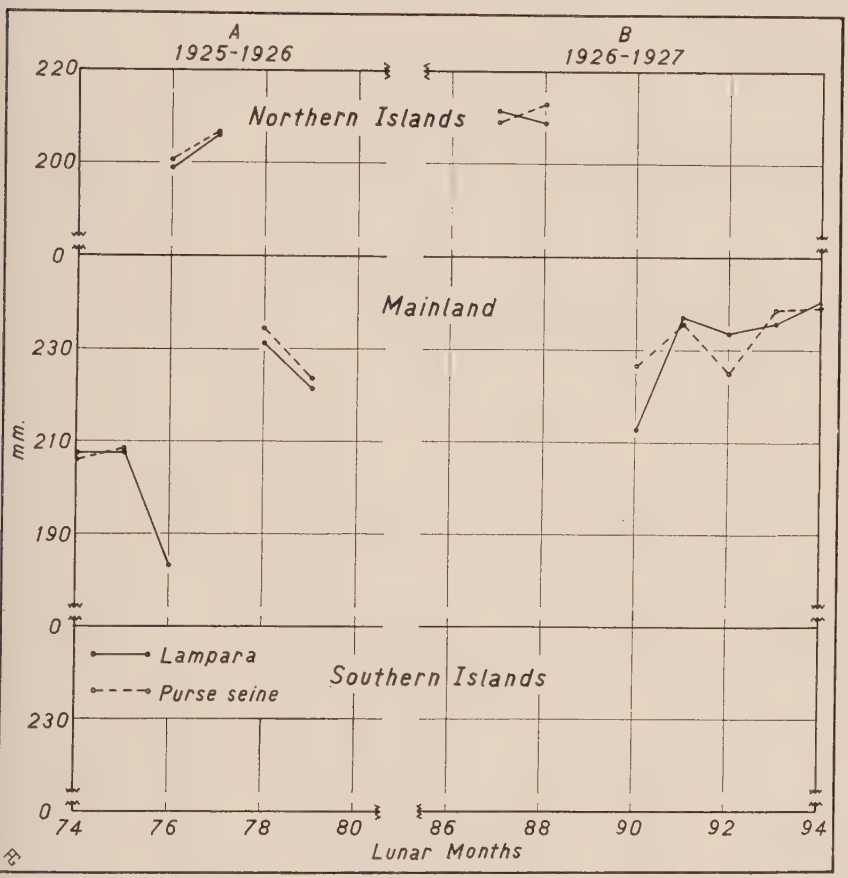

FIG. 18. A comparison of the average body lengths of sardines taken by lampara and by purse seine nets in the northern island, mainland and southern island fishing areas. A—for 1925–1926. B—for 1926–1927. Lunar months 74 and 86 roughly correspond to the month of October in each year.

fish to contrast with the average. However, in figure 18B and table 7B, the mean lengths of the sardines taken by the two types of gear for the 1926–1927 season are compared. Out of eight comparisons in three areas the purse seine fish average larger than the lampara caught fish in three cases, and the lampara fish average larger than the purse seine caught sardines in five cases. The two seasons' data are somewhat conflicting, but as these are all the data available for such a comparison,

some conclusion must be drawn. Combining the comparisons of the two seasons, 1925–1926 and 1926–1927, into one table, the result is:

Purse seine fish exceed, in average length, lampara fish	8 times
Lampara fish exceed, in average length, purse seine fish	6 times
Total number of comparisons	14

Certainly this table does not show that either type of gear consistently catches larger sardines than the other.

TABLE 7

Average Body Lengths of Purse Seine Caught Sardines by Areas for 1925-1926 and 1926-1927

—A—

1925-1926

Northern Island

Purse Seine			Lampara		
L.M.	Males and females	Av. body length (mm.)	L.M.	Males and females	Av. body length (mm.)
76	800	200.47	76	900	198.93
77	450	206.55	77	250	206.12

Mainland

74	250	206.20	72	800	207.78
75	450	208.45	75	500	207.78
76	---	-----	76	800	183.36
77	---	-----	77	---	-----
78	750	234.52	78	900	231.20
79	600	223.52	79	700	221.07

—B—

1926-1927

Northern Island

87	1450	209.12	87	50	211.76
88	800	212.62	88	150	208.87

Mainland

90	600	226.91	90	200	212.81
91	550	236.02	91	150	237.51
92	700	224.54	92	300	233.86
93	150	238.32	93	850	235.88
94	50	239.10	94	500	240.61

Southern Island

91	800	230.61	91	100	230.72

As to the statistical significance of the means and the difference between means in any lunar month, it is shown in table 8 that all means calculated from fifty or more cases are statistically significant, and all differences of two millimeters or more between means, when both means are composed of fifty or more cases, are statistically significant.

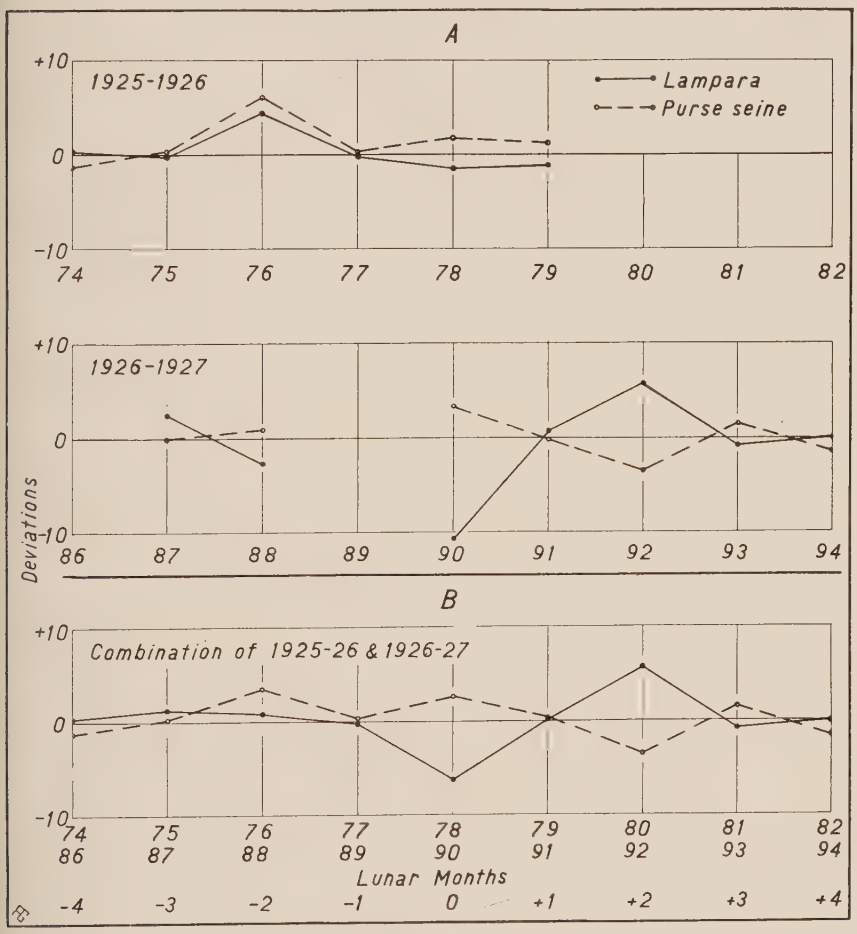

FIG. 19. A—The average mean-deviations of the sizes of sardines from the average of all data by lunar months, of the lampara and of the purse seine caught fish for the seasons 1925–1926 and 1926–1927. B—Combinations of the deviations by comparable lunar months of the 1925–1926 and 1926–1927 seasons. Lunar months 74 and 86 roughly correspond to October.

TABLE 8

Standard Error of Means and of Differences Between Means of the Sizes of Sardines Taken in the Los Angeles Harbor Fishing Region in 1929-1930

L.M.	N	Area	Mean (mm.)	σ_M	M_1-M_2 (mm.)	$\sigma_{(M_1-M_2)}$
124	200	No. Island	192	.530	2	.613
124	550	Mainland	194	.304		
125	850	No. Island	199	.273	1	.574*
125	450	Mainland	200	.502	2	.585
125	700	So. Island	202	.300		
126	750	No. Island	207	.476	2	.670
126	250	So. Island	205	.471		
127	800	Mainland	221	.855	1	1.214*
127	450	So. Island	222	.863		
129	250	No. Island	243	.968	0	1.117*
129	700	Mainland	243	.559		

*Not statistically significant.

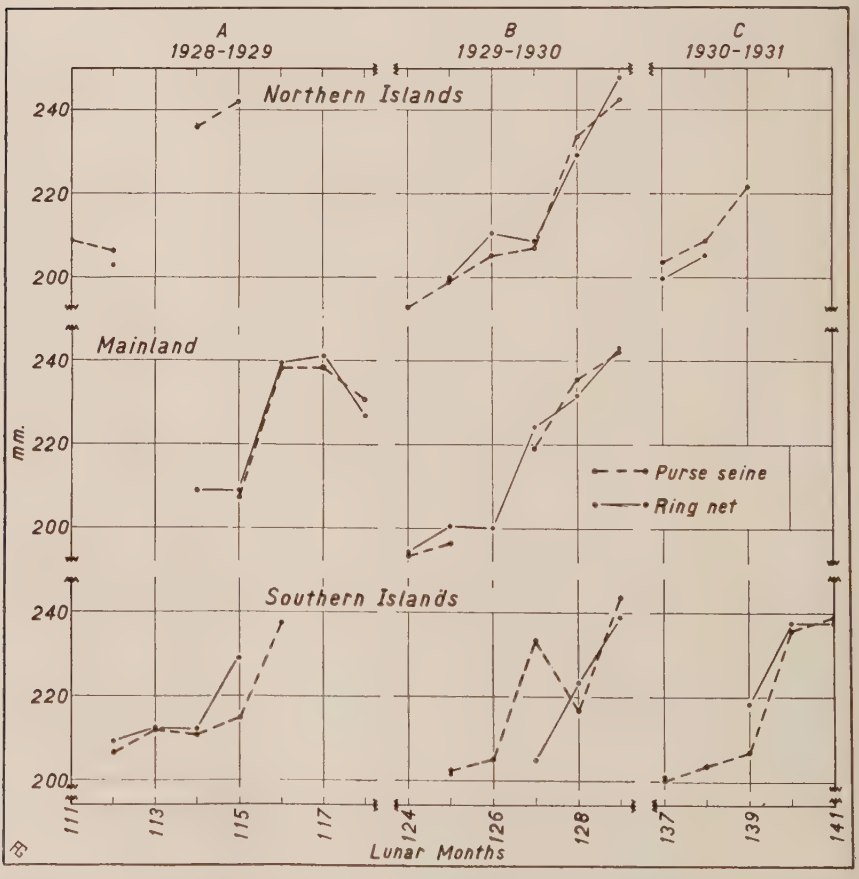

FIG. 20. A comparison of the average body lengths of sardines taken by purse seines and by ring nets in the northern island, mainland and southern island fishing areas. A—1928–1929. B—1929–1930. C—1930–1931. Lunar month 111 corresponds to October; 124 to October 19—November 17; and 137 to November.

As a further check on the differences of the sizes of sardines taken by these two types of nets, the average deviations of the lengths of sardines taken by each type of gear, from the mean lengths for all data in each lunar month, were calculated. (See table 9.) These are shown for the seasons of 1925–1926 and 1926–1927 in figure 19A, in which these two average deviations are contrasted. In 1925–1926, the purse seine caught fish have on the whole more plus and less minus deviations than the lampara caught sardines (purse seine 5 plus and 1 minus, lampara 2 plus and 4 minus deviations). This would indicate that the purse seines caught larger average sizes of sardines than the lamparas. However, in the next season (1926–1927) the pluses and minuses of the two types of gear are equal (purse seine 3 plus and 4 minus, lampara 3 plus and 4 minus deviations). Each year's data seem to belie the other, consequently, the two years were combined by comparable lunar months for each type of gear. The lunar month in which the transition of size of the sardines occurred in each season, that is, the change in size from the smaller fall fish to the larger winter fish, was termed the "zero" lunar month, and the deviations of the mean lengths of fish caught by the two types of gear were combined to form an average deviation for the "zero" lunar month. Then working forward and backward in each season from the lunar month representing "zero," the deviations of the other lunar months were combined for each type of gear. The result of these combinations of deviations by gear in the two years is shown graphically in figure 19B and numerically in table 9 (A and B). From the pictogram of the combination, the plus and minus deviations for the two types of gear are more nearly similar than in the previous graph, although for the purse seine caught sardines the plus deviations still exceed those for the lampara, but obviously the 1925–1926 data greatly influenced the combinations. The combined data show the following results:

	Deviations
Purse seine fish	6 plus
	3 minus
Lampara fish	5 plus
	4 minus

Again, from the deviations there is no clear-cut and consistent difference of the average size of sardines taken by lampara and purse seine nets. There seem to be merely fluctuations back and forth; first, fish caught by one type exceed those taken by the other gear, and *vice versa*. It would appear from the evidence and data on hand that the sizes of sardines taken by purse seine and lampara gear are due to chance and that neither type of gear consistently takes smaller or larger fish.

Purse Seine and Ring Nets

The ring net and the purse seine have been used for the past three seasons, 1928–1931, inclusive, in the San Pedro sardine fishery. A comparison for each season of the mean lengths of fish taken by these two types of gear by lunar months and areas is shown in figure 20 (A, B and C) and table 10. From the sardine average body lengths (in millimeters) both in the tables and in the graphs, one notes that

the fish caught by ring nets in many cases average greater in size than those taken by purse seines. It is also apparent that the average size of sardines caught by these two nets fluctuates back and forth, so that from the graphs and tables one can not tell readily which average exceeds the other in the greater number of cases. Therefore, this comparison of the types of gear is summed up as follows:

Out of 30 comparisons of mean lengths, the ring net exceeded purse seine fish 19 times, and the purse seine fish exceeded the ring net sardines 11 times.

Here again as in the comparison of the purse seine and lampara caught fish, there is no outstanding gear that consistently catches larger sardines. True, the sizes of ring net fish exceeded those sizes taken by purse seines a greater number of times, but not always or in even three-fourths of the cases.

TABLE 9

Mean Length Deviations of Sardines Taken by Purse Seines and Lampara Nets from the Average Lengths of All Sardines in Each Lunar Month

—A—

1925-1926

L.M.	No. Island		Mainland		So. Island		Average	
	P.S.	L.	P.S.	L.	P.S.	L.	P.S.	L.
74			—1.20	+ .38			—1.20	+ .38
75			+ .35	— .32			+ .35	— .32
76	+6.03	+4.49					+6.03	+4.49
77	+ .15	— .28					+ .15	— .28
78	+1.81	—1.51					+1.81	—1.51
79	+1.32	—1.13					+1.32	—1.13
Average	+2.33	+ .39	— .42	+ .03			+1.41	+ .27

1926-1927

87	— .09	+2.55					— .09	+2.55
88	+ .92	—2.83					+ .92	—2.83
89								
90			+3.20	—10.90			+3.20	—10.90
91			+2.67	+4.16	—2.74	—2.63	— .03	+ .76
92			—3.43	+5.89			—3.43	+5.89
93			+1.55	— .89			+1.55	— .89
94			—1.53	— .02			—1.53	— .02
Average	+ .41	— .14	+ .49	— .35	—2.74	—2.63	+ .07	— .58

—B—

1925-1926 and 1926-1927 Combined by Comparable Lunar Months. Average Deviations

Lunar months		Purse Seine	Lampara
74 and 86	—4	—1.20	+ .38
75 and 87	—3	+ .13	+1.11
76 and 88	—2	+3.47	+ .83
77 and 89	—1	+ .15	— .28
78 and 90	0	+2.50	—6.20
79 and 91	+1	+ .42	+ .13
80 and 92	+2	—3.43	+5.89
81 and 93	+3	+1.55	— .89
82 and 94	+4	—1.53	— .02

TABLE 10

Average Body Length of Purse Seine and Ring Net Caught Sardines by Areas for 1928-1929, 1929-1930, and 1930-1931

—A—

1928-1929

Northern Island

Purse Seine			Ring Nets		
L.M.	Males and females	Av. body length (mm.)	L.M.	Males and females	Av. body length (mm.)
111	540	208.83	---	---	-----
112	300	206.16	112	50	202.92
113	---	-----	113	---	-----
114	---	-----	114	---	-----
115	100	236.18	115	---	-----
116	248	242.18	116	---	-----
Mainland					
114	---	-----	114	150	209.15
115	274	207.45	115	616	209.15
116	375	238.26	116	925	239.39
117	250	238.49	117	250	241.05
118	450	230.96	118	756	226.88
Southern Island					
112	900	206.45	112	250	209.34
113	750	212.10	113	650	212.35
114	525	211.37	114	700	212.28
115	350	215.17	115	350	229.20
116	100	237.75	116	---	-----

—B—

1929-1930

Northern Island

124	200	192.48	124	---	-----
125	600	198.78	125	250	199.62
126	450	204.84	126	250	210.41
127	550	206.96	127	200	208.54
128	150	233.59	128	150	229.39
129	200	242.37	129	50	247.80
Mainland					
124	300	193.46	124	250	194.37
125	50	196.42	125	400	200.56
126	---	-----	126	200	200.15
127	225	219.19	127	525	224.28
128	350	235.64	128	225	231.70
129	100	242.03	129	600	243.15
Southern Island					
125	250	202.43	125	450	201.96
126	250	205.46	126	---	-----
127	266	233.86	127	184	204.92
128	100	216.76	128	525	223.56
129	50	243.94	129	250	238.89

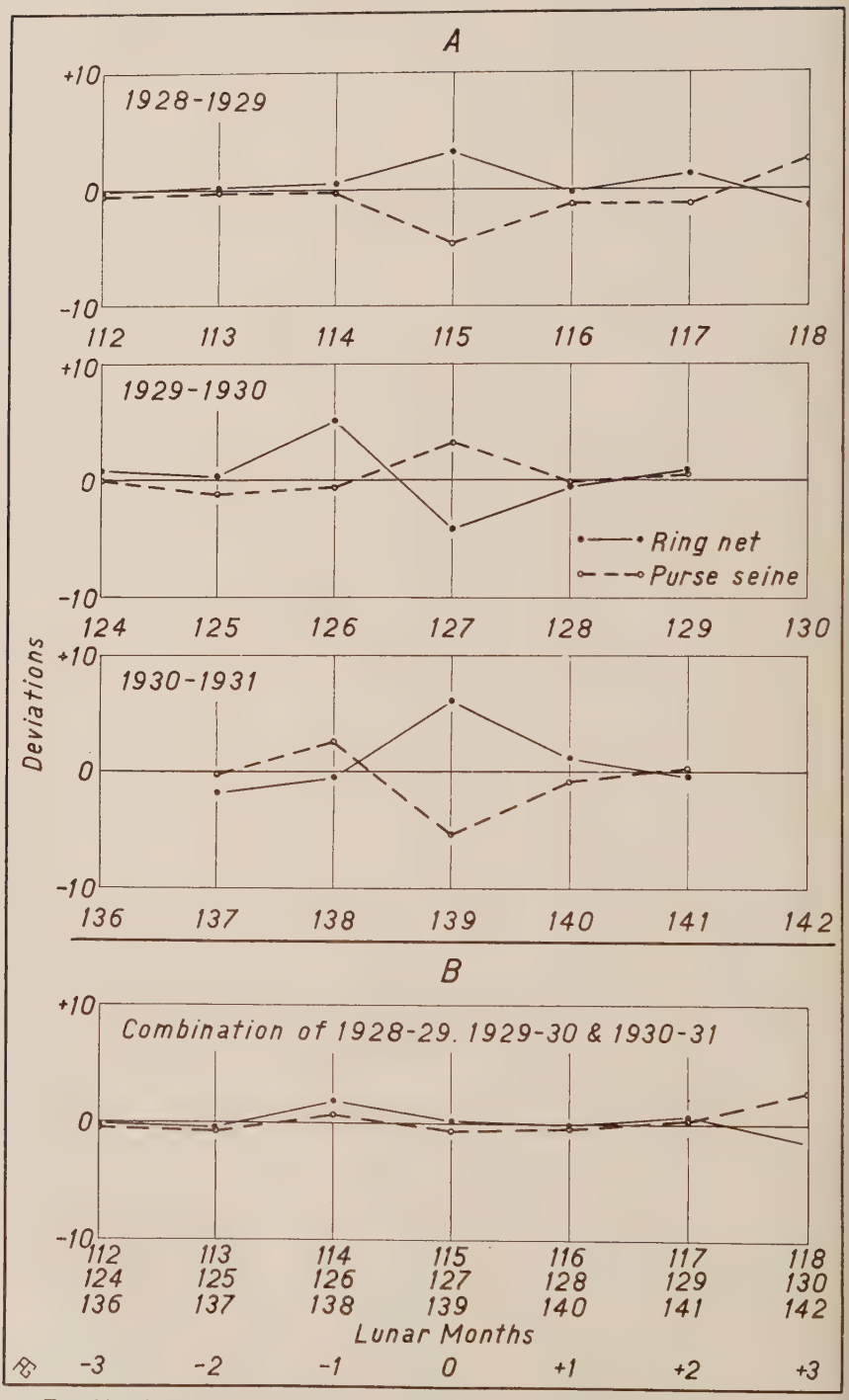

FIG. 21. A—The average mean-deviations of the sizes of sardines from the average of all data by lunar months, of the purse seine and ring net caught fish for the seasons 1928–1929, 1929–1930 and 1930–1931. B—Combination of the deviations by comparable lunar months of the 1928–1929, 1929–1930 and 1930–1931 seasons.

—C—

1930-1931

Northern Island

137	675	203.92	137	300	199.82
138	525	208.86	138	225	205.84
139	113	221.82	139	---	-----
140	---	-----	140	---	-----
141	100	238.77	141	---	-----

Mainland

141	50	238.40	141	300	237.67

Southern Island

137	100	200.02	137	50	201.12
138	450	203.68	138	---	-----
139	925	206.85	139	662	218.31
140	800	235.98	140	700	237.93
141	650	238.40	141	400	237.75

The deviations of the mean lengths of fish of each type of gear from the average lengths of sardines for each lunar period, including all gear and all areas, are given in table 11 and shown graphically in figure 21A. The deviations, as given in the figure, are the average deviations of all areas by lunar months. The deviations in the season, 1928–1929, indicate that the sardines taken by ring nets tend as a whole to deviate above the normal, whereas the purse seine caught fish deviate below the norm in more cases. The deviations in the two seasons, 1929–1930 and 1930–1931, do not show such a tendency on the part of the ring net caught fish, instead sizes of fish caught by the two types of gear offset each other.

	Ring net fish deviations	*Purse seine fish deviations*
1928–1929	4 plus	1 plus
	3 minus	6 minus
1929–1930	4 plus	2 plus
	2 minus	4 minus
1930–1931	2 plus	2 plus
	3 minus	3 minus
	10 plus	5 plus
	8 minus	13 minus

From the above summation of the deviations, sardines taken by ring nets seem to be above normal in 50 per cent more cases than those caught by purse seines, and the fish caught by purse seines are below normal in almost 50 per cent more cases than fish caught by ring nets. In figure 21B, the average size deviations for the three seasons are combined, using as a starting point the lunar month in which the sizes of fish change, and then combining the deviations of the sardines each lunar month forward and backward from this point. It will be noticed in this chart that the fluctuations are reduced to a minimum and that the deviations of the mean lengths of sardines taken by the two types of gear follow each other very closely:

	Deviations
Ring net fish	3 plus 4 minus
Purse seine fish	3 plus 4 minus

Each type of gear in the combination curve shows the same number of plus and minus deviations from the average, but if the number of times the ring net caught fish exceed the purse seine fish is enumerated, the result is different:

Ring net sardine deviations are above those of purse seines	6 times
Purse seine sardine deviations are above those of ring nets	1 time

The results of this last calculation then tend to show that ring net caught fish average larger than those taken by purse seines, and the summary of the comparison of the mean lengths indicates that there was little difference between the average sizes of sardines by gear. Definite proof that the two types of gear caught consistently different sizes of fish is lacking as is concrete evidence that the gears consistently caught about the same sizes of fish.

TABLE 11

Mean Length Deviations of Sardines Taken by Purse Seines and Ring Nets From the Average Lengths of All Sardines in Each Lunar Month

1928-1929

L.M.	Northern Island		Mainland		Southern Island		Average	
	P.S.	R.N.	P.S.	R.N.	P.S.	R.N.	P.S.	R.N.
111	---	---	---	---	---	---	---	---
112	— .59	—3.83	---	---	— .30	+ 2.59	— .44	— .62
113	---	---	---	---	— .12	+ .13	— .12	+ .13
114	---	---	---	---	— .21	+ .70	— .21	+ .70
115	---	---	—8.41	—6.71	— .69	+13.34	—4.55	+3.31
116	---	---	—1.19	— .06	---	---	—1.19	— .06
117	---	---	—1.28	+1.28	---	---	—1.28	+1.28
118	---	---	+2.56	—1.52	---	---	+2.56	—1.52
Av.	— .59	—3.83	—2.08	—1.75	— .33	+ 4.19	—1.14	+ .66

1929-1930

124	---	---	— .04	+ .87	---	---	— .04	+ .87
125	—1.59	— .75	—3.95	+ .19	+ 2.06	+ 1.59	—1.16	+ .34
126	— .53	+5.04	---	---	---	---	— .53	+5.04
127	—9.71	—8.13	+2.52	+7.61	+17.19	—11.75	+3.33	—4.09
128	+4.86	+ .66	+6.91	+2.97	—11.97	— 5.17	— .07	— .51
129	+ .17	+5.50	— .27	+ .85	+ 1.64	— 3.41	+ .51	+ .98
Av.	—1.36	+ .46	+1.03	+2.50	+ 2.23	— 4.68	+ .52	— .28

1930-1931

137	+1.57	—2.53	---	---	— 2.33	— 1.23	— .38	—1.88
138	+ 2.53	— .49	---	---	---	---	+2.53	— .49
139	---	---	---	---	— 5.46	+ 6.00	—5.46	+6.00
140	---	---	---	---	— .91	+ 1.04	— .91	+1.04
141	---	---	+ .29	— .44	+ .29	— .36	+ .29	— .40
Av.	+2.05	—1.51	+ .29	— .44	— 2.10	+ 1.36	— 57	+ .28

Average Length Deviations of 1928-1929, 1929-1930, and 1930-1931 Combined by Comparable Lunar Months

L.M.		Purse seine	Ring net
112 124 136	—3	— .31	— .12
113 125 137	—2	— .73	— .43
114 126 138	—1	+ .60	+1.75
115 127 139	0	— .76	+ .06
116 128 140	+1	— .46	— .11
117 129 141	+2	+ .14	+ .57
118 130 142	+3	+2.56	—1.52

Since there is no definite proof of larger or of the same sized fish being taken by different types of gear, but there is a fluctuation back and forth of the sizes of sardines caught by the gear discussed, it seems reasonable to believe that these variances are due to chance. If one type of gear selected larger fish by reason of its construction or for any other cause, then it would be expected that such a type of gear would always—not just occasionally—select larger fish. Such is not the case, and what holds true for one type of gear one month or season does not hold for another lunar month or season. It would, therefore, seem that chance catching of sardines, chance selection of schools of fish by different fishermen, and chance occurrence of larger or smaller fish in a given restricted area are the causes of the variance between sizes of sardines taken by the three types of gear.

COMPARISON OF SIZES OF SARDINES BY FISHING AREAS

From the foregoing discussion it may be reasonably concluded that the gear does not affect the sizes of sardines caught, so a comparison of the sizes of fish taken in the three areas (northern island, mainland and southern island) in the Los Angeles Harbor district may be made without regard to gear.

Data from six seasons are available for comparisons of the sizes of fish taken in the areas. Comparisons are made by lunar months, using frequency curves for three seasons and means and deviations for six seasons.

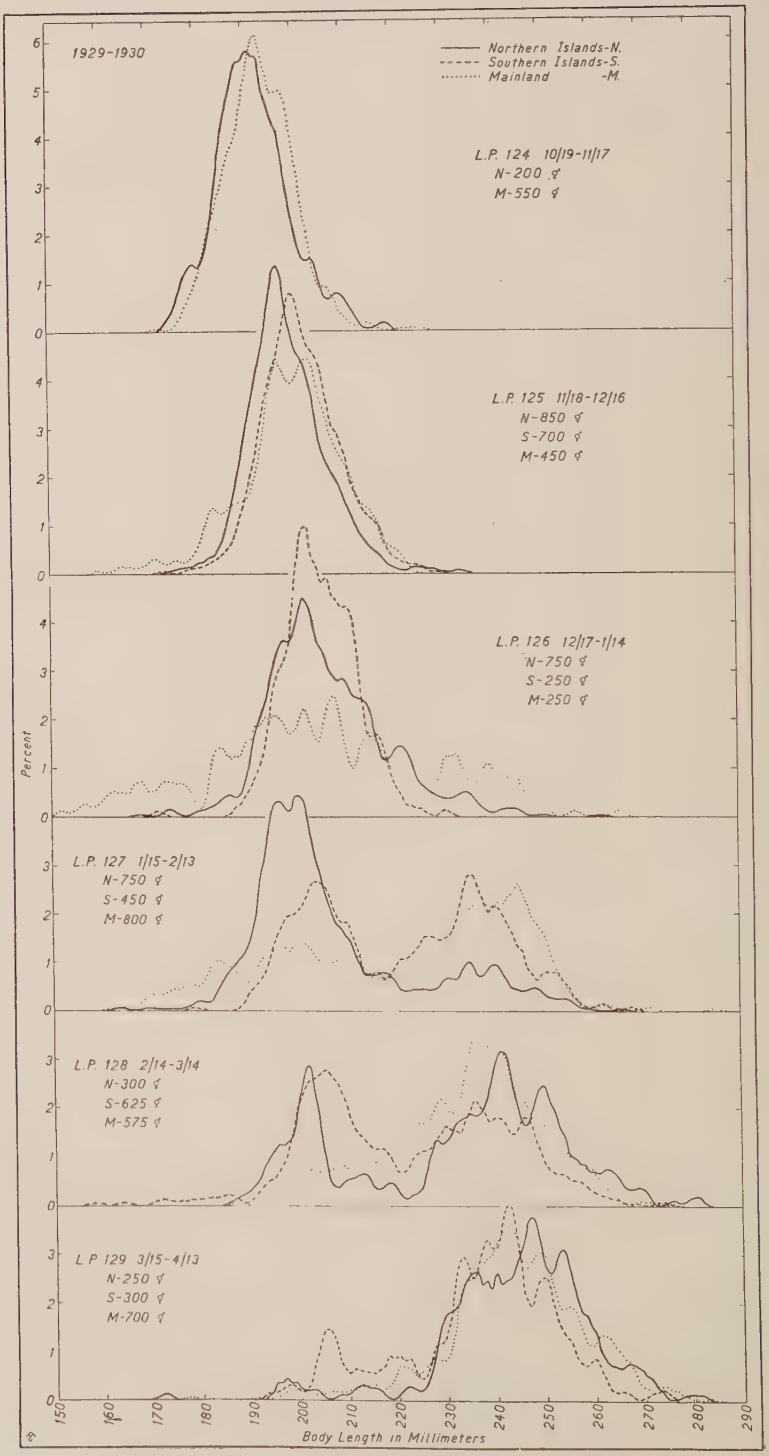

FIG. 22. Frequency curves of sardine body lengths by lunar months and fishing areas for the 1929–1930 season.

Size Frequency Curves

In order that a conception of the complexities of the sardine population within these three areas may be obtained, the frequency curves for one complete season, 1929–1930, (Fig. 22) and the transition periods for two seasons, 1926–1927 and 1928–1929, (Fig. 23) are presented. The frequencies of the body lengths of sardines are plotted by lunar months for each area for the 1929–1930 season in figure 22. The frequency curves for each area are nearly alike until the third period (126) is reached. In this period is noticed the spreading out of the frequency polygon composed of the mainland fish; this marks the beginning of the transition period at which time the large winter fish come into the fishing grounds. In the lunar month 126, the fish from the two island areas have not changed in size to any great extent, for the frequency curves do not show the influx of large fish. However, in the following lunar month all three areas show the presence of the larger fish as well as the small fall fish. The mainland area frequency curve shows a greater predominance of the large fish over the small than do the frequency polygons for the other areas; the southern island curve is made up of about half and half; and the northern island area is still essentially composed of the small fish. Lunar month 128 demonstrates still further this gradual change in the sizes of fish in that the mainland frequency curve is almost entirely made up of large fish, and the island areas still retain a part of the small fish group although they have a higher percentage of big fish. Finally, in the last lunar month shown (129) the frequencies of the three areas are similar, all showing most of their percentage in large winter fish.

This progressive influx into and the diffusions through the fishing region of the different sized sardines are most interesting and important, especially in view of the facts later presented in this report. It would appear from the above and from figure 22 that the large fish first began to appear in the mainland area (that is, in the 1929–1930 season large sardines were taken by commercial fishermen first in this area). Next, it would seem that the large sized fish invaded the southern and northern island areas. This change took place during the three lunar months, 127, 128 and 129, and in each of those months the modes of the frequency curves are widely different, but especially are the mean lengths of the fish in the area frequencies at variance. It is readily seen that a comparison of the mean lengths of sardines by areas during these three periods would differ from each other greatly, with perhaps the mean lengths of the mainland fish always exceeding.

Now the question arises: Do the large sardines appear first in the mainland fishing area or do they sometimes first invade other sections? The answer has a direct bearing on the sizes of fish in each area and particularly on any comparison of mean lengths of sardines by areas.

In figure 23, the frequency curves by areas of the fish taken in the two lunar months in which the transition occurred in 1926–1927 and 1928–1929, are plotted. In these frequencies lies the answer to our question. In both the 1926–1927 and 1928–1929 seasons the larger sardines appeared first in the commercial catch in the northern island area, with the large fish next making their appearance in the southern island section and lastly in the mainland section. Here the procedure of the 1929–1930 season (Fig. 22) is reversed by the appearance of the

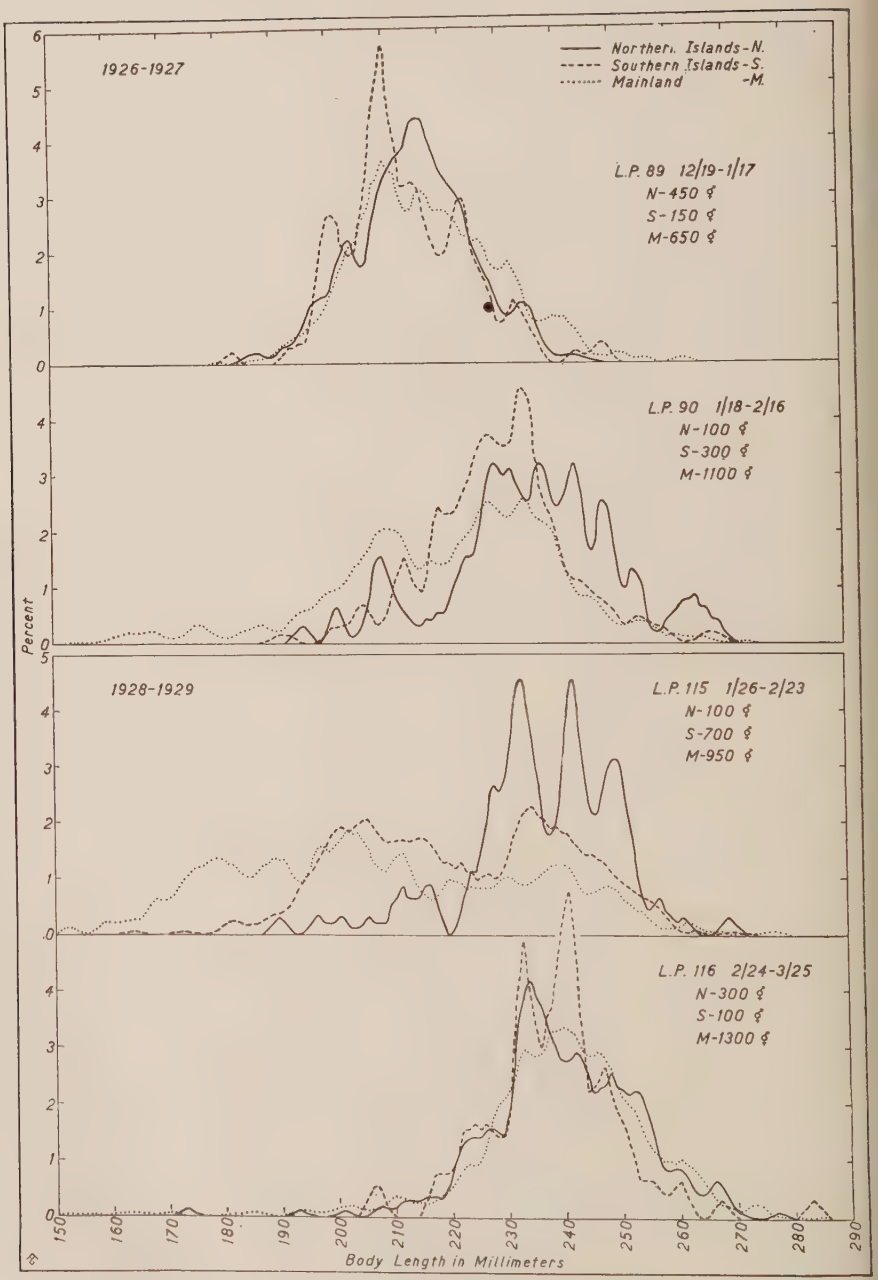

FIG. 23. Frequency curves of sardine body lengths by fishing areas for two lunar months in the 1926–1927 season, and for two lunar months in the 1928–1929 season.

winter fish first in the northern part of the fishing region. Naturally, this would reverse the magnitude of the mean lengths of the mainland and northern island areas for these two months. In the six seasons covered by the data, the large winter fish were first taken in the northern island area four times and twice in the mainland.

Other studies indicate that the main body of large winter sardines comes from the north into the San Pedro fishing region to spawn south of Point Conception. (Scofield, E. C., 1934.) The more frequent first appearance of these large winter sardines in the northern island area may be caused by this influx from the north of maturing sardines. These fish, however, are not always taken first in this northern part of the San Pedro region and it seems probable that chance plays an important role in determining where the large winter fish will first be taken by the commercial fishermen. They may be found first in the northern island area, the mainland area or perhaps the southern island area but not consistently in any one of the three areas.

From the above frequency curves of each area for the transition period, it is demonstrated that the mean lengths of fish in the months during the change in sizes can not be relied upon to give a true measure of the sizes of fish for each area during the entire season. For instance, if by chance the large sardines first appeared in the fishing district in the same area for three consecutive years, then very likely the mean lengths of the fish from that area would exceed those of the other areas in all lunar months in which the change of sizes occurred. This obviously would greatly over-balance the average lengths over a period of a few years as well as magnify the seasonal curves for the three years in question. Likewise, if deviations from a common base were used for all areas by lunar months, the deviations during the transition period for the area in which the large fish first appeared would be out of proportion to the other areas in which the winter fish had not yet penetrated. Again, if by chance the large fish appeared in a different area within the district during each succeeding year, the influence of the high averages caused by the transition period would compensate each other over a period of years, provided there was a long enough series of years for each area to receive due weight. Chance or whatever other factor may be responsible, however, does not act as a careful selector of a different area in which the large fish first may enter each year, but may favor one area for one year, then shift to some other locality the next. As seen from the above discussion it behooves us to be extremely cautious in interpreting the meaning of the comparison of average lengths that are presented below.

Comparison of Average Lengths

Unfortunately, data for each area every lunar month in each season are not available. As a rule, fishermen start the sardine season in November by making their catches in the northern island section. (Fig. 17.) Later in December, they also fish in the southern island area, and still later in the season they carry on their activities in the mainland and southern island sections, perhaps not even making any catches in the northern island area. However, during the last three

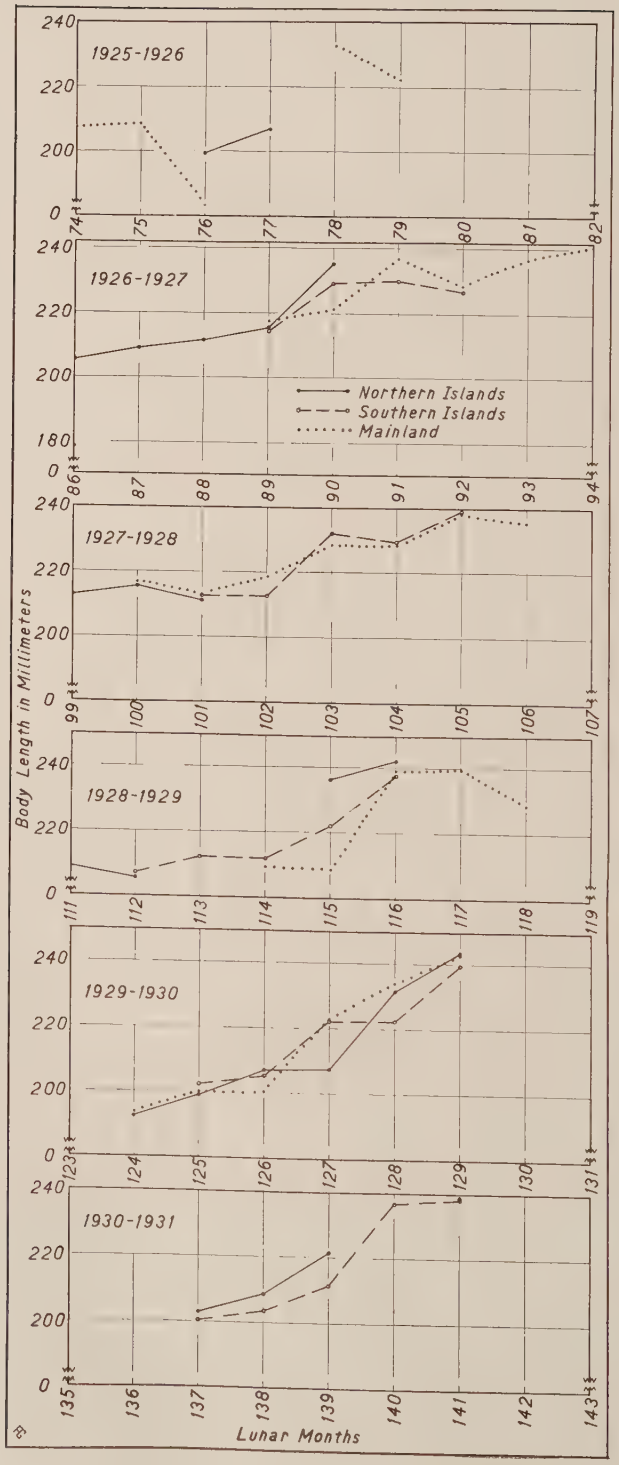

Fig. 24. Comparison of the average body lengths of sardines taken in the northern island, southern island and mainland fishing areas for the seasons 1925-1926 to and including 1930-1931. Lunar months 74, 86, 111, and 123 roughly correspond to October; 99 to November; and 135 to September.

seasons, noticeably in 1929–1930, the tendency has been for the fishermen to fish in all areas each lunar period, so that comparisons of the average sizes of fish by sections became more numerous and complete for the entire season. The importance of having all three areas for comparison during an entire season becomes apparent from the frequency curves presented.

In table 12 are presented the mean body lengths (in millimeters) of sardines by lunar months for six seasons for all areas; the comparisons of these mean lengths are shown graphically in figure 24. Out of 42 lunar months, only 27 comparisons of either two or three areas can be made. There are 15 comparisons of the mainland and northern island, 18 of the mainland and southern island, and only 11 comparisons of fish from all three sections. The following table summarizes the six seasons:

Northern Island and Mainland—	
Northern island fish exceed mainland fish	8 times
Mainland fish exceed northern island fish	7 times
Mainland and Southern Island—	
Mainland fish exceed southern island fish	9 times
Southern island fish exceed mainland fish	9 times
Northern and Southern Island—	
Northern island fish exceed southern island fish	12 times
Southern island fish exceed northern island fish	4 times
All Areas—	
Northern island fish exceed both mainland and southern island fish	6 times
Mainland fish exceed both southern and northern island fish	4 times
Southern island fish exceed both northern island and mainland fish	1 time

From the above summation of the mean lengths, it would seem that the mainland and northern island areas and the mainland and southern island areas furnished sardines that were about the same size. However, in the comparisons between the northern island and southern island sections, the northern island fish far exceed those of the other. Although the comparison of the three areas together indicates that fish from the northern island are slightly larger than those from the mainland, the southern island fish are far smaller in length than the other two. In the first two cases mentioned above, we have the northern island and the mainland fish practically equal in the number of times each exceeds the other in average length. For the mainland and southern island sardines, each exceeds the other an equal number of times. Obviously, there is no consistent showing of greater average sized fish in one area over the other in either of these two cases. However, in the third example of the northern island and southern island fish, there seems to be a tendency for the northern island fish to be larger than those of the southern island in a ratio of almost three to one. Further, when the comparison of the sizes of fish of all areas is made, the southern island fish have a tendency to be smaller than the sardines of the other two areas, whereas neither the northern island nor the mainland fish differ to any marked degree. Table 13, figure 25 and the following summary show the fish of the two island sections grouped by lunar months and the resulting average compared to the mainland fish. Out

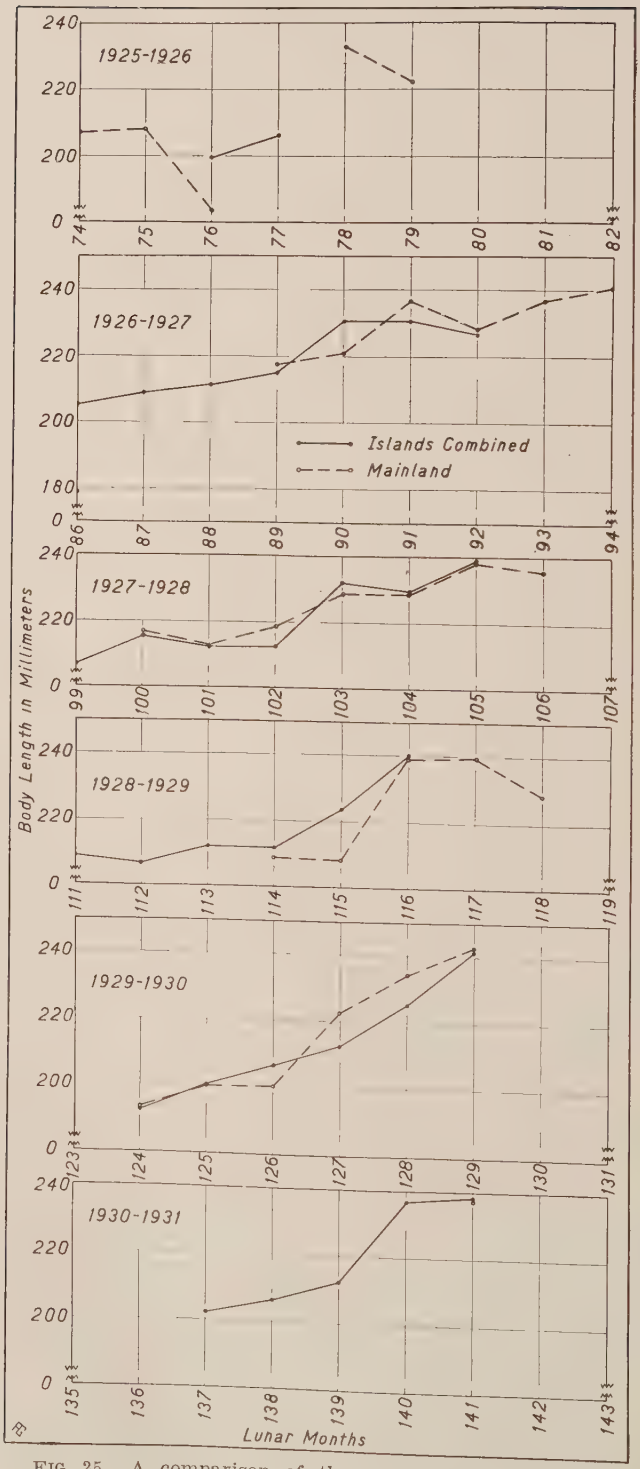

FIG. 25. A comparison of the average body lengths of sardines taken in the mainland and in the combined island fishing areas for the seasons 1925–1926 to and including 1930–1931.

TABLE 12

Average Body Lengths of Sardines From the Three Fishing Areas, Without Regard to Gear, for 1925-1931, Inclusive

1925-1926

L.M.	Northern Island		Mainland		Southern Island	
	Males and females	Av. body length (mm.)	Males and females	Av. body length (mm.)	Males and females	Av. body length (mm.)
74	----	----	1050	207.40	----	----
75	----	----	950	208.10	----	----
76	1700	199.65	800	183.36	----	----
77	700	206.40	----	----	----	----
78	----	----	1651	232.71	----	----
79	----	----	1300	222.20	----	----

1926-1927

86	250	205.68	250	178.83	----	----
87	1500	209.21	----	----	----	----
88	1000	211.70	----	----	----	----
89	450	215.52	650	217.84	150	214.20
90	100	235.21	1100	221.12	300	229.37
91	----	----	750	236.72	1000	230.83
92	----	----	1150	228.37	350	226.67
93	----	----	1250	236.77	----	----
94	----	----	750	240.63	----	----

1927-1928

99	1250	212.89	----	----	750	197.06
100	1000	215.86	750	216.62	----	----
101	50	211.18	700	212.75	750	212.68
102	----	----	1525	218.68	375	212.86
103	----	----	1750	228.72	500	232.02
104	----	----	1850	228.63	300	229.92
105	----	----	1250	238.09	250	239.04
106	----	----	250	235.92	----	----

1928-1929

111	500	208.83	----	----	----	----
112	350	205.69	----	----	1150	207.07
113	----	----	----	----	1400	212.22
114	----	----	150	209.15	1225	211.89
115	100	236.18	890	208.62	700	222.18
116	248	242.18	1300	239.07	100	237.75
117	----	----	500	239.77	----	----
118	----	----	1206	228.40	----	----

1929-1930

124	200	192.48	550	193.87	----	----
125	850	199.05	450	200.11	700	202.13
126	700	206.83	200	200.15	250	205.46
127	750	207.38	750	222.75	450	222.03
128	300	231.49	575	234.10	625	222.47
129	250	243.46	700	242.99	300	239.73

1930-1931

137	975	202.65	----	----	150	200.37
138	750	207.93	----	----	450	203.68
139	113	221.82	----	----	1587	211.63
140	----	----	----	----	1500	236.89
141	100	238.77	350	237.77	1050	238.15

TABLE 13

Average Body Lengths of Sardines Taken in the Combined Island Areas and in the Mainland Area for 1925-1931, Inclusive

L.M.	Islands combined		Mainland	
	Males and females	Av. body length (mm.)	Males and females	Av. body length (mm.)
1925-1926				
74	----	-----	1050	207.40
75	----	-----	950	208.10
76	1700	199.65	800	183.86
77	700	206.40	----	-----
78	----	-----	1651	232.71
79	----	-----	1300	222.20
1926-1927				
86	250	205.68	250	178.83
87	1500	209.21	----	-----
88	1000	211.70	----	-----
89	600	215.19	650	217.84
90	400	230.83	1100	221.12
91	1000	230.83	750	236.72
92	350	226.67	1150	228.37
93	----	-----	1250	236.77
94	----	-----	750	240.63
1927-1928				
99	2000	206.95	----	-----
100	1000	215.86	750	216.62
101	800	212.59	700	212.75
102	375	212.86	1525	218.68
103	500	232.02	1750	228.72
104	300	229.92	1850	228.63
105	250	239.04	1250	238.09
106	----	-----	250	235.92
1928-1929				
111	500	208.83	----	-----
112	1500	206.76	----	-----
113	1400	212.22	----	-----
114	1225	211.89	150	209.15
115	800	223.93	890	208.62
116	348	240.91	1300	239.07
117	----	-----	500	239.77
118	----	-----	1206	228.40
1929-1930				
124	200	192.48	550	193.87
125	1550	200.23	450	200.11
126	950	206.47	200	200.15
127	1200	212.87	750	222.75
128	925	225.39	575	234.10
129	550	241.43	700	242.99
1930-1931				
137	1125	202.35	----	-----
138	1200	206.33	----	-----
139	1700	212.31	----	-----
140	1500	236.89	----	-----
141	1150	238.21	350	237.77

of six seasons, only 22 comparisons of this kind could be made, with the following results:

Island fish exceed, in average length, the mainland fish	12 times
Mainland fish exceed, in average length, the island fish	10 times

The above would indicate that there was no consistent difference in the sizes of fish taken in the combined island areas and in the mainland. This, after all, is an important point because the original sardine fishery was conducted in the mainland section and the island areas constitute the extension of the fishing grounds. Therefore, if the fish of the island areas are essentially of the same size, then these extended sections furnish about the same average sized sardines to the fishery. Of course, chance may show that sardines in one area or the other are larger in a certain day or lunar period, but in the next lunar month chance may reverse the procedure and show the predominance in the other section, and in the final analysis we can not demonstrate size differences for the areas. The chance catching of larger fish is shown more clearly by the frequency curves here presented.

It will be noticed from the frequency curves (Figs. 22 and 23) and from figure 24 that the large winter fish did not first appear in the southern island area in any season. This seems to indicate that fish from that area are always smaller in size in the mean length comparisons, for the average lengths of one or the other of the areas always exceed the mean lengths of the southern island fish in the lunar month of the transition period. This perhaps accounts for the fact that the mean lengths for the southern island area almost always are exceeded by the averages of the other areas as shown in the above table. The influence of the transition influx of fish is strongly demonstrated in the deviations of the mean lengths of fish in the three areas from a common base.

When the data for the two island areas are combined, the resulting average lengths give comparisons which form a clearer and more accurate picture of the relationship between the sizes of sardines in the island and mainland areas.

Deviations from Average Lengths

The deviations of the mean lengths of fish in each area from the average length of all fish for each lunar month are shown in table 14, and the average deviations of each area by seasons are shown graphically in figure 26. This seasonal comparison was not influenced by dominant groups or the transition periods because the deviations by lunar months are from their own season's average. Of course, only for those lunar periods when fishing was carried on in two or more areas have deviations been calculated. From the graphic picture (Fig. 26) of the average deviations by seasons for each section, it will be noticed readily that the northern island fish exceeded in average length those of the two other areas in every case but one. With the exception of the first year, the mainland and southern island fish deviations are similar. These data are an example of the influence of the transition periods on the mean lengths and on the deviations from a common base of the mean lengths of the fish from each area. The fact that in four out of six seasons the large winter fish were first taken in the northern island

TABLE 14

Mean Length Deviations of Sardines Taken in Areas From the Average Lengths o All Sardines in Each Lunar Month

1925-1926

L.M.	Northern island		Mainland		Southern island		Average
	+	—	+	—	+	—	
76	5.21	----	----	11.08	----	----	—2.93
Av.	5.21	----	----	11.08	----	----	—2.93

1926-1927

86	13.16	----	----	13.69	----	----	— .26
89	----	1.05	1.27	----	----	2.37	— .72
90	11.50	----	----	2.59	5.66	----	+4.86
91	----	----	3.37	----	----	2.52	+ .42
92	----	----	.40	----	----	1.30	— .45
Av.	7.87	----	----	2.25	----	.13	+ .99

1927-1928

99	5.94	----	----	----	----	9.89	—1.97
100	----	.33	.43	----	----	----	+ .05
101	----	1.48	.09	----	.02	----	— .46
102	----	----	1.15	----	----	4.67	—1.76
103	----	----	----	.73	2.57	----	+ .92
104	----	----	----	.18	1.11	----	+ .46
105	----	----	----	.16	.79	----	+ .31
Av.	1.38	----	.10	----	----	1.68	— .36

1928-1929

112	----	1.06	----	----	.32	----	— .37
114	----	----	----	2.43	.31	----	—1.06
115	20.32	----	----	7.24	6.32	----	+6.47
116	2.73	----	----	.38	----	2.10	+ .08
Av.	7.33	----	----	3.35	1.21	----	+1.68

1929-1930

124	----	1.02	.37	----	----	----	— .33
125	----	1.32	----	.26	1.76	----	+ .06
126	1.46	----	----	5.22	.09	----	—1.22
127	----	9.29	6.08	----	5.36	----	+ .72
128	2.76	----	5.37	----	----	6.26	+ .62
129	1.16	----	.69	----	----	2.57	— .24
Av.	----	1.04	1.17	----	----	.32	— .05

1930-1931

137	.30	----	----	----	----	1.98	— .84
138	1.60	----	----	----	----	2.65	— .52
139	9.51	----	----	----	----	.68	+4.41
141	.66	----	----	.34	.04	----	+ .12
Av.	3.02	----	----	.34	----	1.32	+ .72

Seasonal Average Deviations Without Considering Transition Lunar Month Means
(See Fig. 27)

Season	Northern island	Mainland	Southern island
1926–1927	—1.05	+1.68	—2.06
1927–1928	— .90	— .11	+1.12
1928–1929	+ .83	—1.40	— .49
1929–1930	+ .61	+ .19	—1.99
1930–1931	+ .85	— .34	—1.53

area makes the deviations very large for the period of the change of size; these large deviations in turn have great weight in determining the average deviation for that area in any season. Consequently, the data for the transition period in each season were discarded, together with three other lunar months' data that were considered too scanty or which were questionable. Then a new average deviation from the

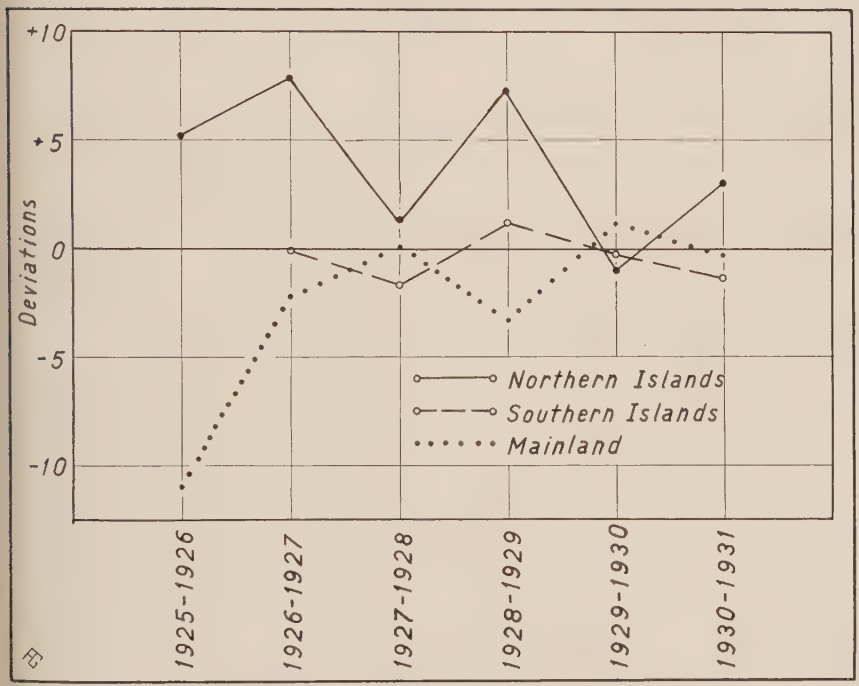

FIG. 26. The average mean-deviations of the sizes of sardines from the average of all data, by seasons, for fish taken in the northern island, southern island and mainland fishing areas. All data are included in the averages.

average of all data for each area in each season was calculated. (Fig. 27.) The fish from the three areas are perhaps in a more rightful relationship to each other in this last calculation. From the 1926–1927 to the 1930–1931 seasons, inclusive, the mainland and northern island fish seem to have no consistent differences in sizes; also the average for the five seasons for the two areas is about equal. The deviations of the average length of fish from the southern island, however, are below one or another of the other two areas except for one year. This

apparent consistent low deviation of the southern area is very likely due in this case, as stated above, to the apparent small sizes of the fish from the southern island section during the lunar periods directly before and directly after the transition period. It will be noticed from figure 24 that the mean lengths of the southern area fish run as a rule a middle course between the other two areas, so they have not the advantage of fluctuations which greatly increase the seasonal average in the mainland and northern island areas. The following table shows the average of the five seasonal average deviations for each area, each season being given equal weight in the calculations:

Northern Island Fish	Mainland Fish	Southern Island Fish
+0.07	+0.004	—0.99

The greatest degree of difference is between the southern island and northern island sardines, but this is so small, being only 1.08 mm that it seems negligible.

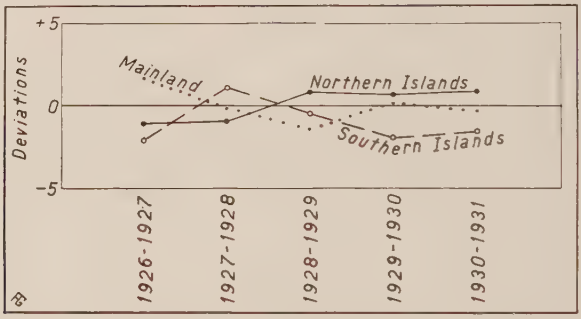

FIG. 27. The average mean-deviations of the sizes of sardines from the average of all data, by seasons, for fish taken in the northern island, southern island and mainland fishing areas. Data from the lunar months in which the sizes of the fish change are not included.

SUMMARY

This study of the effects of the change of fishing apparatus, the extension of fishing grounds in 1925–1926, and the change in gear in 1927–1928, on the sampling system and the investigation of the California sardine has yielded the following results:

None of the three types of nets (purse seine, lampara and ring) consistently catches larger average sized sardines.

The large winter sardines may first be taken during any season in any one of the three areas (northern island, mainland or southern island) of the Los Angeles Harbor region. During the six years covered by this study, however, they were taken first in the northern island area most frequently.

In none of these three areas do the sardines consistently average larger.

The samples of the commercial sardine catch taken in past years are comparable to those taken by the present (1931) gear and in the present extended fishing grounds.

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